Accelerator Safety Implementation Guide

for

DOE O 420.2A, SAFETY OF ACCELERATOR FACILITIES

Office of Science
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This document is an aid to understanding and meeting the requirements of DOE O 420.2A, *Safety of Accelerator Facilities*. It does not impose requirements beyond those stated in that Order or any other DOE Order. An accelerator safety program may not need to fully implement all sections of this guidance to satisfy the requirements of DOE O 420.2A; a graded approach, based on the complexity and hazard class of the accelerator facility, can be used when applying this document. The Guidance is not intended as an audit/assessment tool and should not be used as such without prior agreement between the contractor and DOE.

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Introduction

i. Application and Scope

This guide was developed to aid the effective and consistent implementation of DOE Order 420.2, *Safety of Accelerator Facilities*, (11-05-98) and the updated DOE Order 420.2A (01-08-01), which reflected administrative changes required to bring the Order into compliance with the National Nuclear Security Administration (NNSA) and to update Organization titles. This guide is non-mandatory and references only those requirements contained in DOE Order 420.2A (hereafter referred to as the Accelerator Safety Order or ASO). While this guide provides approaches to satisfactorily implement the ASO, alternative methods may be used to satisfy Order requirements by providing an equivalent level of protection. The term "shall**"** denotes ASO requirements and is followed by a citation of the particular ASO requirement it references. ASO requirements will appear in **bold type** in the guide.

The scope of the ASO, and hence the target audience for this guide, is all DOE accelerator facilities that are not explicitly excluded in section 3.c. of the Order. For purposes of the ASO, an accelerator is defined as a device employing electrostatic or electromagnetic fields to impart kinetic energy to molecular, atomic or sub-atomic particles and capable of creating a "radiological area**"** as defined in Title 10, Code of Federal Regulations, Part 835, *Occupational Radiation Protection*.

Requirements of the ASO apply to the entire accelerator facility, which entails the accelerator itself in addition to experimental areas and associated plant and equipment utilizing or supporting the production of accelerated particle beams and to which access is controlled to protect the safety and health of persons. Uncontrolled office and support spaces are not considered part of the accelerator facility for the purposes of the ASO.

In some instances, portions of what is traditionally defined as the accelerator facility must be categorized as a nuclear facility because of the presence of significant quantities of nuclear materials. Requirements in nuclear safety rules and orders supersede the ASO for those portions of a facility that have been designated a nuclear facility. The facility may be segmented such that a portion of it is a nuclear facility and the remaining areas are an accelerator facility. An example of facility segmentation may be the categorization of an accelerator target and handling area containing a significant quantity of tritium, as a DOE nuclear facility. The remainder of the accelerator complex may be categorized as a DOE accelerator facility for purposes of applying safety and health requirements if it can be shown that hazards of the accelerator area are independent of the nuclear area. DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE 5480.23, Nuclear Safety Analysis Reports*, provides guidance on the issue of nuclear facility classification and segmentation. The initial application of the criteria of DOE-STD-1027-92 only establishes that a facility is a candidate nuclear facility based on material quantity. The final categorization is a determination, made by the responsible Cognizant Secretarial Officer (CSO), which takes into account the form and dispersibility of the radionuclides present.

Compliance with DOE Order 420.2 requirements could be enhanced by appropriate application of DOE Policy 450.4, *Safety Management System Policy*, and DOE Policy 450.3, *Authorizing Use of the Necessary and Sufficient Process for Standards-Based Environment, Safety and Health Management*. The intent of both the ASO and SMS Policy is to ensure that work is performed safely, making them mutually complimentary. An Integrated Safety Management System would provide the management framework for describing the continuous cycle of planning, implementing, reviewing, and improving the actions that an organization takes to meet its environmental, safety and health (ES&H) obligations, which are important aspects of the ASO. DOE Policy 450.3, referred to as the "Work Smart Standards," establishes the process for selecting the ES&H standards to adequately protect the workers, the public, and the environment. When correctly implemented, the WSS would provide the means to applying a graded approach for ES&H safety requirements for accelerator operations. While neither an ISMS nor WSS are required for accelerator authorization, successful implementation of both policies would lend additional credence to safe operation of the accelerator.

ii. Background

DOE Order 420.2A is the successor to the original DOE Order 5480.25, *Safety of Accelerator Facilities*. Almost all of requirements in DOE 420.2A were directly distilled from DOE 5480.25 so the impact of the revised Order on current accelerator facilities in compliance with DOE 5480.25 should be minimal. The basis of DOE approval of accelerator facility activities remains the contractor submission of Safety Assessment Documents, an Accelerator Safety Envelope and Accelerator Readiness Review reports, with subsequent DOE review and approval of the ASE. Accelerator facilities are not required to resubmit these documents, or their equivalents, if DOE has already reviewed them and found them acceptable. However, reviewing and updating, as appropriate, the SAD and ASE should be part of an on-going self-assessment program.

Given the broad range in size and complexity of accelerators within the scope of this Order, the contractor is expected to satisfy the requirements in a graded manner consistent with the hazards present. That is to say that while the contractor is expected to comply with all requirements from which they are not specifically exempted, the rigor and level of detail afforded implementation of each requirement may vary dependent upon the specific hazards at the facility.

Past experience has demonstrated that a review of personnel safety and health provisions by an ad-hoc panel of independent accelerator experts has proven valuable early in the design phase of a new facility or significant modifications to an existing facility. These independent reviews can be valuable in pinpointing weaknesses in design and providing suggestions to optimize construction and operation phases. These efforts not only enhance safety but in many cases can reduce or eliminate the cost of retrofitting safety systems or providing additional controls. The costs avoided entail both financial resources and the loss of experiment time associated with delayed construction and approval to commission or routinely operate.

iii. Issues Associated with the Revision of the Accelerator Safety Order

Exclusions. The revised Accelerator Safety Order (ASO) retains the three exclusions of the original ASO, DOE 5480.25, *Safety of Accelerator Facilities*. Three additional exclusions have been added to the revised ASO [§§ 3.c.(4), 3.c.(5), and 3.c.(6)] and are discussed below.

- Non-medical X-ray devices with the capability of accelerating particles to energies not greater than 10 MeV, which are operated in accordance with American National Standards Institute (ANSI) N43.3-1993, *General Radiation Safety-Installations Using Non-Medical X-Ray and Sealed Gamma-Ray Sources, Energies Up to 10 MeV*, or in accordance with another applicable consensus standard as directed by the cognizant field element manager/NNSA field manager. [§3.c.(4)]

  Machine-produced low energy X-rays are generated by directing accelerated electrons onto a metal target. Electrons with energies below 10 MeV are typically employed for X-ray production. Below 10 MeV, electrons lose energy predominately through ionization and bremsstrahlung processes. Residual radioactivity caused by electrons below 10 MeV is minimal in X-ray production operations because the binding energy of the target nucleons are greater than the maximum electron energy. Targets such as beryllium or deuterium may present residual radiation hazards because of weak binding energies, however they are inefficient for X-ray production and are not used for this purpose.

In the absence of residual radioactivity, exposure to the prompt beam or scatter radiation is the only radiological hazard present. ANSI N-43.3-1993 requirements are adequate for protection from prompt radiation associated with these machines and are more appropriate for accelerators of this type and energy.

- Low-voltage neutron generators incapable of creating a "high radiation area" as defined in 10 CFR 835, *Occupational Radiation Protection; Final Rule*, and which are operated in accordance with National Council on Radiation Protection (NCRP) Report 72-1983, *Radiation Protection and Measurements for Low-Voltage Neutron Generators*, or in accordance with another applicable consensus standard as directed by the cognizant field element manager/NNSA field manager. For the purpose of this Order, a low-voltage neutron generator is defined as a bench-top scale, single-purpose device generating neutrons by accelerating deuterons or tritons into targets through a maximum accelerating potential not greater than 600 kV. [§3.c.(5)]

  A low-voltage neutron generator is a device producing 2.5 and 14 MeV neutrons by accelerating deuterium ions onto a metal tritide target. Capacitors or explosive devices are used to generate the 600-kV or less voltage pulse. The hazards and concerns of neutron generators are more similar to radiation generating devices than accelerators. A radiation generating device is defined in 10 CFR 835 Implementation Guide C3 as "... devices which produce ionizing radiation, sealed sources which emit ionizing radiation, small particle accelerators used for single purpose applications which produce ionizing radiation (e.g., radiography), and electron generating devices that produce X-rays incidentally."

  Like many radiation generating devices, neutron generators are tabletop scale single purpose devices that do not require complex access control systems. In comparison, typical particle accelerators are much larger and entail experimental rooms, which are closed to personnel access by electronic interlocks. Neutron generators induce some radioactivity in surrounding materials, but it is short-lived and in quantities and activities that are below the threshold levels for waste management. However, induced radioactivity within many particle accelerators creates high radiation areas (greater than 100 mrem in one hour) and sometimes very high radiation areas (500 rads in one hour). Dosimetry for neutron generators, while more complex than photon dosimetry, is well established and commercially available. Dosimetry at many particle accelerators is much more challenging due to the presence of exotic particles and high energy neutrons.

In summary, the radiological environment, device size, facility complexity, dosimetry requirements and waste management concerns of neutron generators are similar to those of other radiation generating devices. As such, neutron generators should be excluded from the Accelerator Safety Order provided they are required to operate in accordance with appropriate consensus standards such as NCRP Report #72-1983, *Radiation Protection and Measurement for Low-Voltage Neutron Generators*. Since there is a possibility that these devices may reach a scale such that the above arguments do not apply, this exclusion includes only those devices which are not capable of producing a high radiation area as defined in 10 CFR 835.

- Entire DOE or NNSA facilities or portions thereof where DOE 5480.23, NUCLEAR SAFETY ANALYSIS REPORTS, is applied. [§3.c.(6)]

  This exclusion is necessary to clarify that accelerator facilities to which DOE 5480.23 applies are excluded from requirements of the Accelerator Safety Order based upon the premise that compliance with DOE 5480.23 provides equivalent protection. In some instances, a single accelerator facility may be segmented into multiple areas (target region, linac region, etc.) of which one or more of these areas may be considered a nuclear facility for purposes of safety and health regulation. In these instances, nuclear facility regions are required only to comply with DOE 5480.23 requirements, not "in addition to" the Accelerator Safety Order requirements.

<u>Hazard Classification</u>. The revised ASO eliminates the requirement for hazard classification of accelerator facilities. There is no value-added benefit from the use of hazard classification for DOE/NNSA accelerator facilities because they are intrinsically low hazard in terms of potential for impact (i.e., do not have potential for more than minor on-site or more than negligible off-site impacts to people or environment) to persons or environment outside shielding and accelerator facility containment.

The possibility of any off-site impacts or major on-site impacts is zero for all practical considerations because of the physical characteristics of accelerators whereby 1) they are dependant upon external energy sources (i.e., electric power) which can be easily terminated and; 2) the primary hazard is prompt ionizing radiation which is limited to regions where the beam is allowed and/or persons can be excluded. The removal of the hazard classification requirement does not compromise in any way hazard identification, evaluation, and mitigation, which must be detailed in the Safety Assessment Document (SAD). These actions always are essential components of safety analyses and their documentation provides an important basis for DOE to make a finding that risks for commissioning and operation of the facility are acceptable. Therefore, there is no need for hazard classification and there can be an up-front assignment to the field of DOE approval authority for accelerator facility activities.

The hazard classification requirement was used in the original ASO as an administrative tool to identify the appropriate level of DOE approval authority, in accordance with the former DOE Order 5481.1B, *Safety Analysis and Review System*, which has since been canceled. The implementation of this requirement resulted in resource expenditures for which it was judged that there was minimal, if any, added value to safety. Significant effort was expended in part because of contractors having to provide a thoroughly convincing justification of the proposed classification, based on unnecessarily constraining guidance. As a result of these conclusions, the original guidance for hazard classification was withdrawn on January 2, 1996, and the corresponding Order requirement eliminated with issuance of DOE Order 420.2 (11-03-98). In summary, there is no justified need for (1) hazard classification of intrinsically low-hazard accelerator facilities, or (2) expenditure of resources to establish hazard classification of accelerators that only determine levels of DOE authorization for accelerator activities.

There is no criticality concern because accelerators have no need for fissile or fissionable materials beyond possible trace amounts in some structural materials. Therefore, there are no materials that would be required to sustain a nuclear chain reaction. In addition, most of the activation products (radionuclides) generated in an accelerator are encapsulated within accelerator components themselves and are not contamination concerns. Instances where a classification other than low could be appropriate are related to a radionuclide inventory in excess of DOE-STD-1027-92 inventory thresholds. In these instances, the facility would be a “candidate nuclear facility” and further study would be warranted. If DOE-STD-1027-92 criteria for a nuclear hazard facility were met, it generally would not involve the accelerating device itself, but rather a target or some application of the beam. Such applications of the beam on a target may be designed and conducted in separate facilities appropriately isolated from the balance of the accelerator facility. For such situations, they are addressed appropriately as nuclear safety issues rather than accelerator safety issues. The potential “candidate nuclear facility” status of an accelerator facility in accordance with DOE-1027-92 is not affected by the revised Order.

It also is noted that an equivalent requirement for hazard classification does not exist in the private sector from either state or federal jurisdictions. [The OSHA Process Safety Management of Highly Hazardous Chemicals, 29 CFR 1910.119, might be interpreted as an exception. However it is important to note that all chemicals subject to this regulation must be present on a site in quantities greater than the "Threshold Planning Quantities."] It is standard practice outside DOE for all hazards to be identified and corresponding safety controls implemented in accordance with accepted consensus standards. Where consensus standards are implemented, associated risks for the identified hazards are small and acceptable. Where no safety standards exist for a hazard, an appropriate analysis of the hazards and potential accident scenarios is necessary to determine the controls necessary to limit risks to acceptable levels.

In summary, the requirement for hazard classification has been removed from the draft revised ASO because:

- DOE/NNSA accelerators rarely would require DOE Headquarters CSO/NNSA Deputy Administrator approval of activities as they are low-hazard through intrinsic containment, shielding, and operations design. But, in any case, where an accelerator facility or module of an accelerator facility is not low hazard, the ASO requires the CSO/NNSA Deputy Administrator to approve the Accelerator Safety Envelope, commencement of commissioning activities, commencement of routine operation activities, and exemptions from Order requirements [§ 5.a.(1)].
- There has been little if any benefit from the preparation of documentation used exclusively for establishing a hazard classification for the determination of the appropriate approval authority.
- The cost associated with compiling and reformatting safety analyses information and/or moving the hazard classification documents through contractor and DOE approval chains is not justified and therefore not needed.
- There is no private sector equivalent to or need for the DOE requirement on hazard classification.
- The Order (DOE 5481.1B) that prompted the inclusion of hazard classification within DOE 5480.25 has been canceled.

The current ASO, DOE O 420.2A, assigns the authority to approve Accelerator Safety Envelopes, commissioning, and routine operation of accelerators to the field (DOE Operations Office or Site/Group Office/NNSA Field Manager, as appropriate). Designation of this responsibility to the field is based principally on the localized and highly controllable nature of accelerator related hazards, which leads to low-hazard accelerator facilities by design. As a general practice, field organizations keep the CSO/NNSA Deputy Administrator informed of accelerator safety activities, particularly during the construction and commissioning phases, and also seek CSO participation in the approval process for commissioning and/or routine operation. In any event, the CSO/NNSA Deputy Administrator always has authority to require additional and/or higher levels of approval prior to the undertaking of activities at any facility under their purview. However, where field review of the accelerator design or analysis of experimental data indicates a "potential for more than minor on-site or negligible off-site impacts to people or environment," the Order requires CSO/NNSA Deputy Administrator approval for commissioning, routine operations, and exemptions from the Order.

Shielding Policy. It had been suggested that the revised ASO require the Accelerator Safety Envelope (ASE) include the facility's shielding policy. The value of a shielding policy has not been disputed and this requirement is retained in the revised ASO. Although retained, there is no compelling reason for the shielding policy to be a mandatory part of the accelerator safety envelope. Such a requirement would necessitate resubmission of all currently approved ASEs where shielding was not included as part of the ASE. As there is no additional identified benefit or compelling reason for its inclusion in the ASE, the shielding policy will remain a separate and distinct requirement even though its inclusion in the ASE is not forbidden.

I. Implementation of Requirements in DOE Order 420.2

A. Safety Assessment Document

1. Purpose of Safety Assessment Document (SAD)

The SAD should describe in sufficient detail all significant hazards presented by the facility and its operation, and the controls by which the hazards will be managed. The ASO requires the SAD be found acceptable to the DOE and that it provides detail necessary to determine the appropriateness of the Accelerator Safety Envelope (ASE) prior to approval for Commissioning and Routine Operation of the facility. Where existing information supporting the operation of an accelerator facility is adequately addressed in the documented safety analysis of another activity, its duplication in the SAD is not necessary provided the appropriate references are cited. Pertinent information stored on the World Wide Web (WWW) may be referenced in the SAD; however, referencing applicable documents (e.g., NEPA documents) or electronic media should supplement the SAD, not be used as a substitute for information critical to evaluation of the facility. The SAD itself should contain sufficient summary information to permit an appropriate evaluation of the facility without necessarily obtaining the referenced information.

2. Content of SAD

A Safety Assessment Document (SAD) must identify hazards and associated on-site and off-site impacts to workers, the public, and the environment from the facility for both normal operations and credible accidents [4.a.(1)]. Although the SAD need not include a listing and description of every hazard at the facility, it should be sufficiently detailed to provide DOE confidence that the contractor has performed a comprehensive design analysis. The amount of descriptive material and analysis that needs to be presented will be related to both the complexity of the facility and the nature/magnitude of its hazards inventory.

The SAD must contain sufficient descriptive information and analytical results pertaining to specific hazards and risks identified during the safety analysis process to provide an understanding of risks presented by the proposed operations [4.a.(2)]. The level of detail necessary will depend largely upon the complexity of the facility and magnitude of the hazards. The purpose of the SAD is not only to detail the hazards identified but also to demonstrate that a rigorous study of the activity has been completed and that all significant hazards have been identified.

The SAD must provide appropriate documentation and detailed description of engineered controls (e.g., interlocks and physical barriers) and administrative measures (e.g., training) taken to eliminate, control, or mitigate hazards from operation [4.a.(3)]. It should be demonstrated that controls are sufficient to satisfy requirements and manage identified conditions associated with the hazards. In most instances this does not necessitate quantifying risk, but can be accomplished by qualitatively describing the method that will be implemented to mitigate the hazard to the extent prescribed by the applicable requirements, codes or consensus standards. In some instances, particularly those associated with assessment of radiation dose distribution, quantitative analysis could be the most appropriate method for communicating residual risk.

The SAD must include or reference a description of facility function, location and management organization in addition to details of major facility components and their operation [4.a.(4)]. The description should be of sufficient depth and breadth that a reviewer familiar with accelerator operations but unfamiliar with the particular site and facility can readily identify potential hazards and populations or environments at risk. Site and facility characterization is necessary to provide the framework within which the reviewer can relate accelerator operations to the hazards and potential impacts.

The SAD must be prepared as a single document addressing the hazards of the entire accelerator facility or as separate SADs prepared for discrete modules of the facility such as injectors, targets, experiments, experimental halls, or any other type module [4.a.(5)]. A benefit to the preparation of SAD documents in modular fashion is that changes in hazards or control measures necessitate revision only to those documents describing activities impacted by the changes. An important point for the preparation of modular SADs is that the aggregate assembly or compilation of SADs must comprehensively describe the entire facility in an integrated fashion. Relationships between various operations must be clearly identified and described. Care must be taken to assure than operational changes are integrated into all affected SAD documents.

A separate SAD is not required for an accelerator facility module where the risks are adequately addressed in the documented safety analysis of another operation, because of the integrated contribution of the module to that operation. This means that duplication of effort is not necessary where hazards, control measures and the subsequent risk of operating an accelerator facility module is adequately addressed in documentation for another operation.

The following outline is a generally accepted SAD format, which has proven effective in communicating requisite information to DOE.

<u>Chapter 1: Introduction</u>

This chapter should provide a basic understanding of the facility function and the protection afforded the public, workers (health and safety), and the environment.

<u>Chapter 2: Summary/Conclusions</u>

The summary should provide an overview of the results and conclusions of the analysis contained within the SAD. Comprehensiveness of the safety analysis and appropriateness of the proposed Accelerator Safety Envelope should be addressed. It is also within this chapter that proposed exemptions from the ASO should be identified referencing other sections of the SAD for justification as appropriate.

<u>Chapter 3: Site, Facility and Operations Description</u>

The function of this chapter is to accurately depict the environment within which the facility will be constructed, those facility characteristics that are safety-related and the methods to be used in operating the accelerator and associated equipment. The following items should be addressed in this chapter:

- Characterize the accelerator site location, including any special site requirements or unusual design criteria. Data typically addresses site geography, seismology, meteorology, hydrology, demography and adjacent facilities that may impact or be impacted by the accelerator facility.

- Design criteria and as-built characteristics for the accelerator, its supporting systems and components with safety-related functions should also be detailed in this chapter. Particular attention should be given to those design features which minimize the presence of hazardous environments such as confined spaces, and ensure chemical and radiation exposures are kept ALARA during operation, maintenance and facility modification.

- Administrative functions should be addressed with a presentation of the contractor's and the facility's organizational/management structure and a delineation of responsibilities for safety related actions. The functioning of engineered and administrative controls should be described both for routine operation and emergency conditions. Critical operational procedures to prevent or mitigate accidents should be identified.

- Finally, the experiments which will be conducted in the accelerator facility should be described, including those design criteria and characteristics of the experimental equipment, and systems and components having safety-related functions. This information will likely need to be supplemented as the experimental program evolves.

Chapter 4: Safety Analysis

This chapter should document the analysis, including any systematic methodology (i.e., Failure Mode and Effects Analysis, Fault Trees, etc.) used for the identification and mitigation of potential hazards. It should also characterize and quantify hazardous materials, energy sources and potential sources of environmental pollution at the facility, including radiological hazards. Any analyses conducted per the Process Safety Management Rule (29 CFR 1910.119) should be summarized in the SAD.

Coupled with the identification of hazards should be a description of the controls that will be employed for their mitigation. The description of controls should include discussion of credible challenges and estimates of consequences in the event of corresponding failure. Analysis of estimated consequences and likelihood of occurrence may signify the need for additional or more reliable controls. Description of credible maximum bounding accident scenarios for the accelerator and experiments may be used to indicate the need for and extent of emergency plans or site assistance agreements.

Where appropriate, a discussion of the residual risk to workers, the public and environment should be included. However, a separate effort above and beyond that of the safety analysis is typically not necessary for the purpose of residual risk estimation since requirements, codes, and consensus standards establish acceptable risk.

Implicit in the above discussion is the fact that all analysis of hazards, hazard consequences, and types and reliability of controls involve professional judgement. Professional judgement is supported by sound technical and/or scientific bases using accepted methods for hazard analysis that are valid for the types and magnitudes of hazards present.

<u>Chapter 5: Accelerator Safety Envelope</u>

This chapter consists of the engineered and administrative bounding conditions within which the contractor proposes to operate the accelerator facility. A more complete discussion of DOE's concept of the Accelerator Safety Envelope may be found in section I.B. of this guide.

<u>Chapter 6: Quality Assurance</u>

This chapter should describe the quality assurance (QA) program to be applied to the accelerator facility, focusing upon the activities which impact protection of the worker, public or environment.

<u>Chapter 7: Decommissioning and Decontamination Plan</u>

A description of structural and internal features, which would facilitate D&D of the accelerator facility, should be provided in this section. Waste management of radiological and hazardous material generation from the D&D operation should be discussed within the context of existing DOE requirements.

<u>Chapter 8: References/Glossary/Acronyms</u>

3. Updating the SAD

The SAD must be maintained current and consistent with the administrative control measures and physical configuration of the facility and major safety equipment [4.a.(6)]. The SAD should be maintained such that it accurately reflects the engineered and administrative status of safety systems at the facility. The contractor and DOE organization approving the ASE should agree upon the significance of modifications requiring an update to the SAD. An updated SAD may be required in the event that other DOE requirements are changed such that ES&H at the facility is impacted. The system used to document and implement updates between SAD revisions is left to the discretion of the contractor as long as the associated analyses are available for review. Typically updates are appended to the most current SAD until a SAD revision is conducted.

B. Accelerator Safety Envelope

1. Purpose of an Accelerator Safety Envelope

An Accelerator Safety Envelope (ASE) serves to define the physical and administrative characteristics within which hazards of operation and experimentation can be reduced to acceptable levels and managed using engineered, administrative, and personnel protective controls in place. This is not to say that operations outside the envelope will necessarily result in an accident or unacceptable risk, but that the safety limitations and/or authorization bases approved by DOE for commissioning or operation of the facility are not satisfied. It is expected that all operating limitations of the ASE will be readily verifiable.

The ASO requires strict adherence to the approved bounding conditions of the ASE as it is authorization basis for all commissioning and operations activities. DOE is to be informed, but editorial or clarification changes to an ASE may be made without DOE approval where no bounding conditions are changed and/or where no Unreviewed Safety Issue is involved.

A documented Accelerator Safety Envelope (ASE) must define the set of physical and administrative bounding conditions for safe operations based on the safety analysis documented in the SAD [4.b.(1)]. The basis of the ASE is the safety analysis conducted and appropriately documented in the SAD. While the ASE is a safety driven requirement/document, close communication between accelerator designers and end-users is critical to ensure that machine performance and beam characteristics meet desired specifications while controls are adequate to assure safe operation.

Within its ASE, an accelerator facility can experience unplanned events that interrupt operation but do not compromise safety at the facility. An unscheduled electrical power outage is an example of such an unplanned event. The ASE should be specified so that it is not exceeded by the effects of such unscheduled, but anticipated events with no appreciable safety consequence.

Accelerators should be designed to accommodate transient events during normal operation, such as the partial or total loss of the particle beam, without degradation of safety. Such events would not be expected to exceed the Accelerator Safety Envelope. However, such events may cause beam termination or less efficient operation, which could result in remedial actions being taken because of machine operability or beam quality concerns.

Limits specified in the ASE may apply not only to accelerator operation but also to the conduct of experiments. Where the research mission of the accelerator facility requires frequent reconfiguration, new hardware, new experimental setups or new materials, the careful specification of the ASE is important. The contractor may choose to prepare separate ASEs for each experiment, each group of experiments or include the entire facility and expected experiments into a single ASE.

The contractor may choose to establish an Operations Envelope within the ASE for each group of experiments. By defining the nominal operating parameters beyond which the operating procedures would require adjustments to be made (automatic set points could initiate these adjustments), the Operations Envelope serves to prevent the ASE from being exceeded. Having different Operations Envelopes for different operating modes of an accelerator would be expected, since the combinations of operating parameters may need to change to carry out different sets of experiments. For example, the Operations Envelope may dictate a maximum voltage and beam current for a specific particle whereas the Operations Envelope of a different particle may permit a higher voltage and beam current. Variations of operating parameters within an appropriate Operations Envelope of an accelerator would be considered normal operations. Variation outside the Operations Envelope but within the ASE merits appropriate attention but does not in and of itself necessitate termination of activities or notification of DOE.

2. Content of Accelerator Safety Envelope (ASE)

Accelerator performance parameters are frequently subject to change as experiments change. In defining an ASE, the ranges or correlations of performance parameters within which the accelerator has been shown to operate safely, the minimum instrumentation and equipment, and the associated administrative controls, all need to be considered. Specific limitations and associated equipment requirements should be optimized and restricted to just those needed to ensure safe operation.

Categories of items that should be considered for inclusion in the ASE are:

a) limits on operating variables (such as currents, voltages, energy potentials, beam power, pressures, temperatures, flows) needed to preserve physical barriers or to otherwise prevent excessive short-term or long-term risk to persons;

b) the adopted shielding criteria for different operational modes and resulting radiological conditions;

c) requirements related to the calibration, testing, maintenance or inspection of safety-related systems to ensure their continued reliability;

d) monitoring, release control of ventilation effluent and mitigation measures for the protection of the environment; and,

e) administrative controls such as minimum staffing levels, qualification, and training for operation, minimum operable equipment, critical records to be retained, currency of procedures, and immediate mitigative actions to be taken if the accelerator safety envelope is exceeded.

An alternate approach used at some accelerators involves basing the ASE on specification of radiation levels or potential maximal exposures derived from operational experience and extrapolation of empirical data, in lieu of machine parameters. When carefully applied, use of prior measurements and analyses of empirical data can be used to establish radiation levels or maximal exposures, which are then specified as ASE bounding conditions.

The scope and level of detail given in the ASE generally is a function of the size, complexity and hazards of the operations involved. For a simple accelerator operating in a single room, the safety envelope might be only the maximum beam energy and current. The supporting safety analysis would then show that facility shielding reduces the dose rate in all relevant areas to acceptable levels. If a system operates with several particle types, the impact of the beam that will generate the largest source of radiation exposure would be analyzed, as a minimum. The radiation levels from other type beams would be sufficiently analyzed to demonstrate why they are of lesser consequence than the selected particle beam type.

Radiation levels from some beams may be low enough that it is acceptable for persons to be in or adjacent to target enclosures during operations. If operation is proposed while an area is occupied, the safety envelope should identify acceptable combinations of beam type, beam energy, and current or other critical parameters as well as administrative controls that ensure that no unacceptable levels of radiation will be generated in that area while it is occupied.

For many accelerators, especially large ones, the containment shielding is often not uniformly thick. Here, the safety envelope might include the energies of the beam and loss intensities at various specified locations. The safety analysis would then show that beam interactions and losses from all operations conducted within ASE limits would not cause unacceptable radiation levels or exposures at any location where personnel occupancy is allowed during facility operations.

A target may become radioactive and the beam's energy input might cause it to melt if coolant were lost. Depending on the severity of the potential event, the ASE might require water flow under certain beam conditions but not others. For example, water cooling may not be required for low beam power conditions. The safety analysis should show that, for each feasible adverse event, the mitigated impacts have acceptable risk. If the damage to hardware or the spread of radioactivity from melting the target is unacceptable, then providing adequate cooling would expected to be a normal component of the safety envelope.

The safety envelope should identify those parameters that ensure acceptable operation when the system is operated within them. The examples above apply primarily to radiation concerns, but other safety concerns, particularly those associated with experiments, should be similarly bounded in order to constrain operations within the regions shown to be safe and environmentally responsible.

3. ASE Violation

Any activity violating the ASE must be terminated immediately; the activity must not recommence before DOE or the NNSA has been notified [4.b.(2)]. Upon determination that approved ASE limitations have been exceeded, the contractor should terminate activities impacted by or causing the violations at the earliest time it is safe to do so. The contractor should notify the local DOE authority when an ASE is exceeded and begin an investigation into the cause and consequences of the activity. A report outlining the cause of the incident and describing actions taken to mitigate future occurrences should be completed. DOE should be notified before activities associated with the ASE violation are resumed. Although there is no requirement for DOE approval before resumption of activities, DOE can make that determination on a case-by-case basis when notified.

C. Unreviewed Safety Issue

1. Purpose of Unreviewed Safety Issue Requirement

The requirement concerning Unreviewed Safety Issues (USIs) is a logical extension of the safety analysis requirements set forth in the order, in that activities posing significant safety hazards must not be performed until an analysis of the hazards has been conducted and proper controls implemented. **Activities that involve an Unreviewed Safety Issue must not be performed if significant safety consequences could result from either an accident or a malfunction of equipment important to safety for which a safety analysis has not been performed. Activities involving an identified Unreviewed Safety Issue must not commence before DOE or the NNSA has provided written approval [4.c.].**

2. Scope of Unreviewed Safety Issue Requirement

The identification of a USI is not limited to the startup of new operations. Situations in which a previously unevaluated hazard is discovered in an ongoing operation also are a USI and require that the operation be terminated until an analysis is conducted and controls implemented. In addition, previously evaluated or unevaluated conditions that are found to exacerbate the consequences of a known hazard or increase the likelihood of an unacceptable event are considered USIs and must be dealt with in the same manner.

3. Relationship of Unreviewed Safety Issue to Management of Change Procedures

The Management of Change (MOC) concept has been utilized by private industry to prevent the commencement of operations after changes have occurred without first reviewing the safety implications. Many OSHA standards require this type of review after change to equipment, materials and/or processes occur. A substantive discussion of MOC is located in 29 CFR 1910.119, *Process Safety Management of Highly Hazardous Chemicals*. Implementation of the MOC concept may reduce the likelihood of USIs. It should be noted that a separate and distinct management of change program is not necessary to implement the USI requirement as the concepts of MOC are merely an extension of normal safety analysis performed prior to any change that may affect safety.

Examples of external management of change requirements can be found in OSHA's Process Safety Management Standard (29 CFR 1910.119); Hazard Communication Standard (29 CFR 1910.1200); Emergency Preparedness Standard (29 CFR 1910.38); and the Laboratory Management Standard (29 CFR 1910.1450). These standards require that changes in equipment, processes and/or material be reviewed for new hazards and safety programs be changed accordingly. The MOC concept could be implemented through procedures described in an Integrated Safety Management System Description (DOE P 450.4).

D. Accelerator Readiness Reviews

1. Purpose of Accelerator Readiness Reviews (ARR)

An ARR is not a method for achieving readiness, but for verifying it. An ARR is conducted both to verify the information that is submitted in support of a request to undertake accelerator activities and to assure that the data are comprehensive and address the full scope of activities proposed. An ARR is not an extensive wall-to-wall assessment of all the contractor analyses but rather an overview of the operation, inspection of the hardware and a sampling based on a review of supporting documentation and, if available, past operational experience. The contractor is responsible for conducting the ARR and providing a report to DOE. The ARR team may be composed of DOE employees, contractor personnel and/or consultants although all should possess expertise in the area assigned to them and have reasonable independence from the activity being assessed.

Accelerator Readiness Reviews (ARRs) must be performed prior to approval for commissioning and routine operation and as directed by the Cognizant Secretarial Officer/NNSA Deputy Administrator or a field element manager/NNSA field manager [4.d.]. Generally, an ARR is not required when the contractor identifies a safety concern and subsequently ceases operations to correct the problem. However, whenever deemed warranted, DOE may require an ARR be performed following a self-imposed shutdown by the contractor.

Detailed guidance on the scope, content and conduct of ARR's is presented in Chapter III of this guide.

2. Commissioning in Modules

Commissioning an accelerator facility incrementally can be advantageous, particularly when the contractor desires to operate portions of the facility while others are still under construction. Typically the facility construction will be delineated into modules such as the beam particle source, particle injector, main accelerator, storage ring, experimental halls, etc. As each module is completed and tested, a Commissioning ARR is conducted on that particular module. The commissioning activity for each separate module requires DOE approval before it is initiated unless the contractor receives DOE approval for an overall commissioning program. The development of an overall commissioning program plan tends to focus better the required approval by DOE and lessen the likelihood of delays in obtaining a number of discrete approvals. A commissioning program plan should include:

a. a description of the content of each module;

b. identification of any additional administrative and technical controls and contingency plans beyond those established for prior modules;

c. a description of the content of that portion of the overall facility ARR that is needed for each module; and,

d. the schedule for each module.

E. Training and Qualification

1. Purpose of Training and Qualification

A trained and qualified workforce is essential to the safe and environmentally responsible operation of all facilities, including accelerators. Training serves as the primary means of familiarizing personnel with hazards and communicating the actions required. A qualification process for those personnel whose activities affect the safety and health of themselves or others is necessary to formalize the evaluation of a person's competence to undertake the proposed activity as required. Qualification may be granted based upon a review of a persons credentials and experience or through a formal testing procedure or a combination of both.

2. Scope and Content of Training and Qualification

Training and qualification requirements must be established for each individual at an accelerator facility whose activities could affect safety and health conditions or whose safety and health could be affected by facility activities. Training and qualification must be documented and kept current [4.e.(1)]. The overall training program should be approved by a designated senior line-management official and evaluated periodically for its continued relevance.

An auditable system of records documenting training content and results should be established to demonstrate achievement of training goals. Records recommended for retention include:

- course syllabus
- instructor's handbook
- handouts provided to trainees
- copies of written examinations with date given, answers expected, and results
- attendance sheets

Requirements and processes for measuring proficiency should be established that provide the minimum levels of demonstrated proficiency for qualification to perform safely related functions without direct supervision, and that describe how the acquired qualification will be maintained. A designated line-management official should grant qualification only after verification that requirements have been met. Qualification should be valid for a specified time established by management for each position, by which time the person must be requalified in accordance with established requalification requirements in order to continue to perform in that position. When setting requalification intervals, attention should be given to the frequency and longevity of facility shutdowns for routine maintenance.

Standards and processes should be established for granting exceptions to specific areas of the training program based on education and experience. In all cases, required examinations to establish qualification should be administered to each individual for whom an exception is to be granted, and examination results recorded. The basis for granting an exception should be well documented.

Documentation to be maintained for each individual should include an audit able record of training received, examination results and qualifications acknowledged. Suggested documentation includes:

- education, relevant experience, and most current health evaluation
- most recent graded written examinations in each training element
- written critiques of task performance during training, including tasks observed and overall conclusion of the evaluator
- summary of training attendance, training completed, proficiency demonstrated, and other information used as the basis for judging whether the individual was qualified for confirmation
- copies of acknowledgment of qualification
- documentation of the basis for granting an exception to a training element.

Only appropriately trained and qualified personnel, or trainees under the direct supervision of trained and qualified personnel, are permitted to perform tasks that may affect safety and health [4.e.(2)]. In addition to a general safety orientation addressing facility specific hazards, qualification requirements should be established for operations, maintenance and support personnel, for experimenters, and for such other positions identified in the SAD as requiring specific education, training and experience to carry out their responsibilities safely.

The facility-specific portion of training is intended to communicate information about local work hazards and their control, and to convey knowledge of safe operating procedures. Facility-specific training may include topics such as:

- self-contained breathing apparatus
- controlled entry areas
- hazardous waste generator rules
- radiation safety practices
- facility emergency procedures

- respirator use
- confined space location and rules
- lock and tag process
- control of activated material

The focus of task-specific training is to enhance an individual’s performance of operational tasks and to ensure that an individual has the skills necessary to keep the accelerator or its subsystems operating within the facility ASE. This training is typically “hands-on” with proficiency demonstrated by completing procedures while under the direction of fully qualified personnel. Common task-specific tasks include:

- hoisting and rigging
- particle beam control
- forklift operation
- cryogenics handling
- high voltage manipulations
- compressed gas handling

Accelerator operations personnel training should emphasize an understanding of the basic physics underlying key operations and the development of diagnostic skills for early recognition of abnormal equipment performance. A distinction should be made between the skill and knowledge required for supervisors and for operators.

Training for maintenance and other support personnel should focus on the safety-related accelerator structures, systems and components identified in the SAD, and experimental components and systems that are important to worker safety and health and/or protection of the public and environment. The training should also take into account specific duties the individuals will perform and the level of supervision.

Training for experimenters should address the safety aspects of the facility and relevant safety and health requirements and practices. Experimenters should be required to demonstrate appropriate knowledge of the hazards of the experimental systems with which they are involved, the design features and controls which minimize the risks from those hazards, and the associated ASE, before being permitted to interface their equipment with the accelerator and engage independently in experimental work at the facility.

All personnel assigned to or using the accelerator facility (including emergency response personnel) must be trained in the safety and health practices and emergency plans consistent with their involvement and the hazards present [4.e.(3)]. The general safety orientation provided to all personnel with unescorted access to the facility should at a minimum, address hazards that may be encountered, actions to minimize or mitigate exposure to the hazards, and the person's role in the emergency plan. Specific topics, which may be addressed, include:

- facility first aid capability
- emergency notification
- OSHA orientation
- facility safety characteristics
- radiation safety practices
- fire protection
- security requirements

Personnel should not be permitted unescorted access to the accelerator facility until they have satisfactorily completed the general safety orientation and appropriate portions of the facility-specific training. It is recommended that those personnel who are required to be escorted within the facility receive at a minimum, those portions of the orientation addressing hazard identification, emergency notification and security requirements. For persons who require limited access to the facility or will be on-site for only a short time, providing an escort may be more cost effective than training the individual.

Particular attention should be paid to the training of experimenters since the procedures that they may follow at their home institutions may not be the same of those required at the host DOE institution. Past DOE experience shows that accidents are more frequently associated with the actions of experimenters than the resident staff operating the user facility. It is critically important to assure the proper training of all users of the accelerator facility, regardless of their time in residence because the activities of an experimenter can greatly affect the safety of themselves and others.

F. Written Procedures

1. Purpose of Written Procedures

Written procedures that provide clear instructions for safely conducting activities must be maintained current and consistent with management systems and the configuration of the facility and equipment and must be approved by facility senior line manager in the contractor's organization who are actively involved in the day-to-day operation of the facility [4.f.(1)]. The review and approval of written procedures by technically qualified professionals is essential to assure that the information and instructions provided to workers promote consistency and reflect safe work practices and environmentally sound policy. Issues such as risk and task complexity will dictate the technical disciplines and level of management attention necessary for approval and the frequency of revalidation.

2. Scope and Content of Written Procedures

Written procedures must include a description of the tasks to be performed, appropriate safety and health precautions and controls, and where applicable, requirements for verifying initial conditions, operating conditions to be maintained, and data to be recorded [4.f.(2)]. The actual format of the written procedure can be customized for the specific facility or task but should include the above mentioned information at a minimum. Uniformity in the format of written procedures at an individual facility is highly recommended as it minimizes the possibility of confusion, which can result in an incident affecting safety.

A description of tasks to be performed typically includes the objective of the procedure, a review of the hazards associated with the activity and detailed directions (often in checklist form) for task completion. Requiring the recording of vital data provides a historical account of machine/component performance in addition to keeping operational data at the forefront of a worker's attention. In many cases, abnormal events can be foreseen and prevented/mitigated by noting abnormal variations in machine performance data. Delineation of safety and health precautions and controls serves to sensitize the worker to possible adverse affects associated with the task and provides the actions necessary to reduce risk to themselves and others. Although safety and health aspects are incorporated into the directions for task completion, a section in the procedure reserved for safety and health measures emphasizes their importance and helps the worker anticipate accident scenarios.

At a minimum, the contractor must prepare procedures for operation startup, normal operation, emergency conditions, conduct of

maintenance, approval and conduct of experiments, review and approval of facility modifications, management of safety-related changes, and control of facility access [4.f.(3)]. The scope and level of detail of written procedures is a function of the facility hazards, operational complexity and workforce expertise. Reference USI guidance for further discussion of Management of safety-related changes.

G. Internal Safety Review System

1. Purpose of an Internal Safety Review System

An internal safety review system must be established and maintained to periodically assess and document the condition of the facility, equipment, and engineered safety systems [4.g.(1)]. The DOE requires the contractor to implement an internal safety review system to provide assurance that contractor management has independent feedback on the safety status at the accelerator facility. Documented reviews by a group of experts independent of the operation provides a "reality check" which should complement the findings of self-assessments performed by accelerator operations personnel. Both the internal safety review system and operational self-assessments serve to focus management attention on improvements necessary for continued safe operation. The period between reviews need not be fixed but generally should not exceed three years, which is consistent with requirements for radiological facilities.

2. Scope of an Internal Safety Review System

Appropriateness and implementation of procedures, administrative controls and personnel training and qualifications must be periodically reviewed and documented by the internal safety review system [4.g.(2)]. Membership of the contractor's internal safety review system may be based on one or more standing or ad hoc committees but should be comprised of persons independent of the accelerator operation under review. This group functions primarily in an advisory capacity to a designated manager having the authority to direct actions based upon the review findings. The rigor with which the review system is implemented should be commensurate with the hazard potential of the facility. While the system is intended to be internal to the contractor's organization, independent technical competence in all areas required for an appropriate review may not be readily available within the organization. Consultants from other DOE accelerator facilities could be used as a regular complement to internal staff to provide an additional degree of objectivity and independence as well as nurturing cross fertilization within the DOE system.

Administrative aspects of the review system, which should be clearly delineated in a line management approved document, typically include: purposes; objectives; functions; authority; responsibility and composition of membership; quorum; format of documentation reporting results of reviews; and, the format for responding to and closing out recommendations from the reviews. Documentation of actions taken in response to the internal safety review system's recommendations should also be retained as should the rationale for altering or rejecting recommendations. Documentation of the safety reviews should be in sufficient detail to permit audit of review system performance. Audits of the internal safety review system should be conducted at least every five years by contractor management.

Audits of each accelerator facility by an internal safety review system should be conducted at least every three years and address the physical condition of the facility, record keeping, compliance with or satisfying applicable requirements and performance of the safety training programs. Specific aspects of the accelerator facility which typically merit investigation by the internal safety review system include:

- the safety and environmental aspects of the design of the accelerator facility prior to the start of construction;
- Safety Assessment Documents during their development;
- proposed modifications to the accelerator facility, its operation, or any equipment that has potential safety implications;
- accelerator facility procedures related to safe and environmentally responsible operation;
- approved Accelerator Safety Envelopes;
- whether proposed activities are within the Accelerator Safety Envelopes;
- identified causes of any violation of Accelerator Safety Envelopes;
- corrective actions proposed in response to a facility shutdown because of safety concerns; and,
- the content of safety training programs.

Reviews should not be conducted at arm's length from the activity being reviewed. Interaction with representatives of the facility is encouraged so long as the conclusions of the review are free from pressures and constraints by the program under review. Reviewers should seek to minimize their disruption of activities although facility management should be accommodating to the needs of the reviewers and provide complete access where feasible.

H. Shielding Policy

The contractor must approve and implement a written statement of the shielding policy for ionizing and non-ionizing radiation [4.h.]. The statement on shielding policy called for by the order has not been required to be submitted to DOE for approval. It is sufficient to review the manifestations of this policy in specific applications as they arise.

II. General Guidance

A. Operations

1. Discussion

Accelerator operation may require a high degree of flexibility for the effective execution of experiment programs and/or research and developmental activities; but these activities also must be conducted in a safe and environmentally sound manner. Specific guidelines and appropriate procedures for accelerator operation and for conducting experiments will ensure that a high level of performance is achieved in a safe and environmentally sound manner, and in accordance with applicable rules and regulations.

2. Operation Organization and Administration

Procedures or other definitive documentation should describe lines of authority and responsibilities for the safe execution of program goals, availability of resources and interfaces to other groups, relationships to safety organizations, operations performance, monitoring guidelines, accountability, training policies, and safety planning policies.

3. Shift Routines and Operating Practices

Standards for the conduct of work practices for operations staff should be established. These standards should address adherence to operating procedures and equipment specifications, status awareness and response practices of operations staff, and emergency response requirements. Logkeeping and reporting requirements should also be specified.

4. Control Room Activities

Guidelines for maintaining a professional atmosphere in control centers of the facility should be established, commensurate with the importance of the control room as an operating base and coordination center for important facility activities. Policy regarding authorization for, and supervision of, the operation of equipment should be specified, both for routine shift operation and for research development activities conducted from the main control room.

5. Communications

Guidelines covering the correct use of communications systems including radios, telephones, public address and paging systems should be issued. This should include emergency communications and the announcement of changes in operating conditions.

6. Operations

Operations procedures should be established to provide specific direction, where appropriate, for operating processes, systems, and equipment during normal, errant, and emergency situations. These operating procedures should be designed to ensure that the Accelerator Safety Envelope is not breached, and that facility operation remains within the Operations Envelope if this concept is employed.

7. Conduct of Research and Development

Guidelines should be established to ensure that research and development programs on the accelerator facility are conducted consistent with all facility safety requirements. The guidelines should ensure appropriate safety controls for access of accelerator specialists and experimenters to the facility equipment for the purpose of research, development, and experimentation.

8. Status Control of Equipment and Systems

Procedures should be established to ensure that: the facility configuration is maintained in accordance with design requirements; that status changes are properly authorized; and operating staff are aware of the status of the equipment and systems. Lock and tag procedures, guidelines for status verification, guidelines for Logkeeping and documentation of equipment status, and requirements for shift turnover information should be addressed in this context. There should also be an administrative control to ensure that equipment and components are properly labeled.

B. Access Control

1. Discussion

Control of access at accelerator facilities is necessary to protect the U.S. Government from unnecessary liability because of actual or alleged injury of casual visitors, including trespassers; to protect property from damage or theft; and to provide reasonable assurance that all persons at the accelerator facility are either aware of the potential hazards and the emergency procedures, or are under the guidance of someone who is fully aware of these matters.

2. Unsupervised Occupancy

As part of the plan for control of access, specific consideration should be given to the question of unsupervised occupancy by persons who are not employees of the contractor or the DOE. Researchers at DOE accelerator facilities frequently are not employees of the contractor or the DOE. Although these researchers receive a general orientation concerning facility hazards and more detailed training specific to their experimental activities, granting of unsupervised access facility-wide is normally not necessary.

3. Two-person Rule

Implementation of a two-person safety rule for selected areas of the facility should also be considered. The two-person rule may apply to specific areas of the facility in concert with certain activities such as electrical work, welding or transfer of toxic chemicals.

4. Access Control Mechanisms

Remote mechanisms for access control should be considered for positive assurance that only trained and qualified personnel are permitted entry to hazardous or sensitive locations. Commonly implemented remote access controls include closed circuit television and personnel recognition devices.

C. Beam Interlock Safety System

1. Discussion

The choice of an appropriate beam interlock safety system to prevent employee exposure above permissible limits affects not only the degree of protection afforded individuals, but also the technical and administrative burden. The level of protection provided and the system's reliability are to be appropriate for the hazards present in order to avoid having users disregarding the system on one extreme or be negligent in providing for protection of persons at the other extreme. Where the potential consequences are significant, a major design effort including independent reviews, a rigorous program of testing and maintenance, and well-designed and tightly-run administrative controls should be specified. When radiation levels are not expected to exceed 1 rem in an hour, administrative controls such as procedures, warning signs, and barriers may be suitable replacements for an interlock system. Use of administrative controls in lieu of interlocks may be particularly beneficial for operations that are temporary or utilize portable radiation generators. The interlock system and the administrative controls on it should be discussed in the SAD. Since the installation and maintenance of an interlock system represents a significant technical and administrative burden, the choice and features of a system should be justified by careful safety analysis.

2. Relay-Based versus Computer-Based Systems

Relay-based logic systems have traditionally been used for accelerator personnel protection, and a large body of experience is available. Computer based systems are now widely used in industrial control and have found application in accelerator personnel protection. In addition, Programmable Array Logic (PAL) systems, which are solid-state devices functioning analogous to relays, and Programmable Logic Controllers (PLC), a microprocessor system, are also used for interlock safety systems. Each system has certain advantages and disadvantages that should be considered when selecting an interlock system. For example, relay-based systems can be more difficult to safely modify to meet new requirements, while PALs and PLCs can be modified through programming. Also, “bypass” techniques vary—insertion of a jumper which can be overlooked versus programmed. Guidance in sections 3-7 of this chapter is applicable to both relay-based and computer-based systems. The remaining considerations in this section are specific to the computer-based systems.

a. Computer-based systems are inherently more complex and the failure modes more difficult to analyze than relay-based systems. Consequently, it will be more difficult to demonstrate a satisfactory level of reliability.

b. The following issues should be considered in the selection of a computer-based protection system.

(1) Testing and Design: Operability of software and hardware used in the protection system should be validated and its appropriateness to the task verified.

(2) Modularity: Where parts of the protection system need to be decommissioned for servicing or modification, it should be demonstrated that signals from the portion that has been taken out of service cannot influence the active portion of the system. In general, modularity and isolation is more difficult to demonstrate than in relay-based systems.

(3) Redundancy: Failure modes are particularly difficult to predict in computer-based systems because of their complexity, so redundancy is an important aspect of their reliability. Common cause failures are also difficult to predict because linkages between failures can be subtle. Bugs in the logic software are a possible link. If redundancy is provided by independent computer systems, different programmers, working independently could write the logic software for the systems.

(4) Isolation and Configuration Control: Computers are often linked through various communication channels, and sometimes these links are subtle, such as connections to a development unit for downloading software or serial links for machine status information. Computers used for personnel protection interlocks should be dedicated solely to that task, and all external links should be eliminated or rigidly controlled. Configuration control of the software is even more important than for the physical components since software changes are often hard to detect.

(5) Staff Resources: Staff resources should be adequate for both hardware and software aspects during design, construction, operation and maintenance phases.

3. Technical Design

a. The protective functions of the interlock system should be fail-safe against routine failures, including loss of power or pressure, open circuits, and shorts to ground.

b. Interlocks should be arranged so that no single failure will cause loss of protection.

c. System components should be protected from damage, and cable runs outside of cable trays should be armored cable or in conduit. Alternatively, supervised circuits could be used to ensure circuit integrity.

d. Critical devices are specific accelerator or beam line components that are used to ensure that the accelerator beam is either inhibited or cannot be steered into areas where people are present. Common examples are steering magnets, beam stops or collimators. Other examples are systems that operate on the injector or ion source to inhibit the beam.

(1) Two critical devices should be used in an interlock system if a whole-body very high radiation area, as defined in 10 CFR 835, can be produced.

(2) The status of each critical device should be monitored to ensure that the devices are in the "safe" condition when personnel access is permitted. If only one device is used, two separate indication systems should be provided. If the "safe" condition is lost, the beam should be inhibited by operation of other critical devices upstream. Critical device command systems should be independent of the monitoring systems.

e. Safety devices should not be used as routine shutdown mechanisms, i.e., the equipment design and procedures should provide for an orderly means of turning off beams other than activation of an entry interlock before entry is attempted into a controlled access area. The entry interlocks should not constitute the normally-used means of disabling beam. However, interlocked safety devices should be employed to maintain the disabled status of beams.

f. A strict configuration control system should protect the circuits and functions against unauthorized or inadvertent modification. Critical devices, security and safety devices, and wiring should be clearly labeled to note that tampering is strictly forbidden.

g. The system could be modular in design so the interlocks for different parts of the facility can be serviced independently. This is particularly important for individual experimental areas, which are often shut down for modification while the rest of the facility is running.

h. The system design should allow for complete function testing, with the effort and disruption require by such tests kept within reasonable limits.

i. An independent review of beam interlock system design and the system's testing program should be performed. The findings of that review and the response to the findings should be documented.

4. Personnel Exclusion Areas

a. Emergency shut-off devices, which are clearly visible, unambiguously labeled and readily accessible should be provided in exclusion areas. In addition, interlocked exit doors may be utilized as emergency shut-off devices.

b. Emergency exit mechanisms are required by OSHA standards to be provided at all doors, even when interlocked. Emergency entry features for interlocked doors should not be precluded.

c. Signs or clearly labeled lights reflecting current exclusion area status should be provided at all entry doors.

d. Exclusion areas should be searched before the beam is introduced to ensure that no people remain inside. Procedures to ensure the reliability of the search process should be comparable with the design procedures to ensure the reliability of the interlock system.

(1) Search confirmation buttons, or check stations should be placed to ensure that the search team can view all parts of the area.

(2) After an exclusion area is secured, an audible and visual warning should be provided before the beam is introduced.

(3) If entry control is compromised, the search and warning interval should be repeated before introducing the beam.

e. A “Limited Entry” mode could be desirable for larger accelerators. Under this mode with beam operation excluded, a small number of workers are permitted to enter an already searched area to carry out specific tasks. Strict controls, which include issuing an in-tunnel warning, and well-defined procedures are required for this mode to be acceptable. When tight administrative controls are maintained during this mode, operations can commence after the workers have exited without a further search.

5. Testing of Interlocks

a. Testing (i.e., validation that the system works as designed under conditions of use), should validate the interlock system at least annually. An interlock system should not be used to provide protection unless it has been validated within the specified testing period. A short grace period could be allowed if specified in the administrative procedures. A successful testing program will depend on a system design, which accommodates testing and the commitment of machine time and resources to accomplish the tests. Testing intervals should also take into account the system reliability and the overall reliability design goal as specified by the probability of the protective electronic system to fail on demand of a safety challenge.

b. A functional test should also be completed after modification or maintenance work is done on an interlock system. Those maintenance and service actions, which are deemed to be trivial and which do not require functional testing, could be identified and justified generically or individually.

c. Written test procedures having sufficient detail to ensure a complete functional test of the interlock system should be used. Testing should be executed with a check sheet with a check-off for each observed response, thus providing an audit able record.

(1) The functional test of the interlock system should exercise the system inputs and verify each protective response. If a digital system using software in mission critical applications is employed, then both “black box” functional testing and “white box” structural testing should be performed. The structural testing should include a verification and validation program for the life cycle of the code.

(2) Integrity of redundant interlock chains should be determined.

(3) It is important that critical devices are tested in their operating configuration, and at least once during the test the system should be exercised from end to end. For example, verify that opening an entry door causes the expected result (e.g., a pulsing linac modulator turns off, not just that a relay drops out or a power supply ready light turns off).

(4) Testing should also verify that the system provides protection in response to likely improper actions.

6. Documentation of the Interlock System

The following documentation should be prepared and maintained:

a. a written functional description of the interlock system;

b. the physical and electrical configuration of the system;

c. a description of the document control and review system for keeping documentation complete, accurate, and current;

d. an audit able record of interlock system test results; and,

e. the management approval of the system as described.

7. Administrative Controls on the Beam Interlock System

a. There should be a well defined and rigidly enforced configuration control process that provides a mechanism for the review and approval of changes in the system design and of modifications of function and logic. The detail of the review and the level of approval could be commensurate with the degree of hazard involved.

b. A notable example of modification of function is the bypassing of an interlock. This should be permitted infrequently, under very strict controls and only if equivalent safety is provided by procedures or by alternate equipment. The proposed bypassing should be reviewed and approved by management and the interlock system should be tested with bypass in place and again after it has been removed.

c. There should be a clear definition of the procedures and restrictions on interlock maintenance work, such as:

(1) only authorized persons should do the work;

(2) proper safeguards, e.g. a locked beam stop, should be required before the interlock is taken out of service. The safeguard should be independent from the system being worked on; and,

(3) the system should be returned to service only after suitable testing has been done.

D. Radiation Safety

1. Discussion

The primary standard for DOE occupational ionizing radiation protection is Title 10 Code of Federal Regulations, Part 835. This section deals with program features somewhat unique to accelerators. This section also addresses non-ionizing radiation.

2. Radiation Dosimetry

a. Discussion

The prompt (generated instantaneously by the beam) radiation environments at particle accelerators range from negligible at low-energy heavy-ion accelerators to extremely high intensity at high energy, high current units. The radiation exposure fields differ from those usually found at reactors or nuclear facilities in that they often extend to higher energies and result from cascade phenomena, and therefore typically consist of several types of ionizing radiation distributed over a broad range of energies. In addition, the radiation fields often have a complex time structure, which depends on the accelerator repetition rate, the details of the radio-frequency accelerating system, and the beam extraction systems.

b. Guidance

Since the radiation fields around accelerators are complex, often consisting of many different types of ionizing radiation extending over a broad range of energies, it is not always sufficient to apply the techniques of dosimetry that are known to work well for lower-energy radiation without a clear understanding of the accelerator radiation environment and its interaction with the dosimeter to be used. For example, dosimeters that work well at low neutron energies often have responses to the high-energy particles present in accelerator environments that make proper interpretation of their measurements complicated. Thus, accelerator facilities should document their dosimetry programs for those radiations and energies not included in the Department of Energy Laboratory Accreditation Program for personnel dosimetry by characterizing the radiation fields in terms of particle flux and energy spectra and the dosimeter responses.

3. Radiation Protection Instrumentation

a. Discussion

The radiation fields at accelerator facilities generally have a complex structure and may require monitoring instrumentation to operate in a pulsed radiation field. Varied instrumentation may be required to adequately monitor for personnel protection, beam monitoring, or radiation field assessment.

b. Guidance

(1) Instruments used for radiation protection should be appropriately calibrated for the radiation fields encountered.

(2) Calibrations should use written procedures with sufficient detail, and be consistent with ANSI N323-1978.

(3) The radiation protection instruments should be calibrated at least annually (as per ANSI N323-1978).

(4) An auditable record of calibration results and quality assurance efforts should be maintained.

4. Control of Induced Radioactivity

a. Discussion

For many accelerator operations the largest dose equivalents and much of the collective dose equivalent arise from exposure to induced radioactivity during repair, maintenance, and modification activities. These doses come mainly from gamma radiation resulting from activation of solid, often thick, objects by penetrating radiation. As a result, external gamma radiation normally dominates the exposure and beta dose rates are relatively low.

Much high-energy accelerator induced radioactivity is produced by "spallation," in which a high energy particle strikes a target nucleus causing the emission of possibly several nucleons or larger nuclear fragments. These processes result in radionuclides that tend to the neutron deficient side of the periodic chart stability line. Thus a large part of the accelerator induced radioactivity decays by positron emission or electron capture. In electron capture, the radionuclides can only be detected by their photon emission (important examples are Be-7, Mn-54, and Cr-51).

b. Guidance

(1) Surface Contamination

Some high intensity accelerator facilities can produce significant surface contamination and possible airborne activity, usually because of Be-7 produced by spallation reactions in air or vaporized target materials. Special monitoring techniques may be necessary to assess this contamination.

(2) Activated Material

Much accelerator construction material becomes slightly radioactive, but does not become highly radioactive even after years of service. Because of the penetrating nature of high energy radiation, the radioactivity is usually distributed throughout a sizeable volume of material. If the dimensions of the component are large with respect to the photon mean free path and the radionuclides are more or less uniformly distributed throughout the irradiated material, an accurate estimation of activity concentration can be made by measuring surface dose rates.

For-accelerator produced radioactivity in ordinary materials of construction (i.e., aluminum, copper, iron, concrete, earth, etc.), material that has an activity level of less than 0.4 Bq/g (about 10 pCi/g) is not important radiologically and is considered uncontaminated in Great Britain (G.B.S.I. 1986). However, as required in DOE 5400.5, Chapter II, 5c(6), such materials may be released only when using DOE-approved criteria and survey techniques.

5. Radiation Dose Limits to the Public

a. Discussion

The radiation dose limit via the air pathway to the public from DOE operations, including accelerators, listed in DOE 5400.5 is the EPA regulation (40 CFR Part 61, Subpart H) limit on dose to the public of 10 mrem/year from radioactive gas released to the environment. Since the EPA limit is small compared to typical background exposure (approximately 350 mrem/year at most locations), great care will be required in monitoring to differentiate the incremental dose from radionuclides released to the air. Compliance must sometimes be established by modeling and computation.

b. Guidance

(1) The document "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental

Surveillance" (DOE/EH-0173T) of January 1991 contains the requirements for monitoring releases and assessing-dose to the public. Table 3-1 of that documents shows that emission points causing doses above 0.1 mrem/yr require monitoring.

(2) To keep air releases ALARA, the contractor should consider minimizing the air path that particle beams traverse and maintaining dead-air volumes where beams must pass through air. By keeping air flow slow and the paths long before venting to the atmosphere, the typically short-lived radioactive nuclides can decay.

6. Radiation Protection Program Content

a. Discussion

Code of Federal Regulations, Title 10, Part 835, and "Department of Energy Occupational Radiation Protection" governs radiation protection programs at DOE accelerators. Guides have been developed specifically for 10 CFR 835 and discuss implementation of its requirements.

b. Guidance

(1) SLAC-321, *A Guide to Good Practices for DOE Accelerator Health Physics*, could be used in establishing elements of a health physics program unique to an accelerator facility.

(2) A written statement should be employed to communicate shielding policy for ionizing and non-ionizing radiation. The written statement serves to communicate management expectations and employee responsibilities in addition to emphasizing the importance of proper shielding to minimize exposure to radiation.

7. Magnetic Fields and Non-Ionizing Radiation

a. Discussion

High magnetic fields are present at many particle accelerator facilities. While the health risks from magnetic fields are not well understood, there is an identified hazard to persons with pacemakers. Perceptible or adverse effects have been documented on persons with other implanted ferromagnetic medical devices (suture staples, aneurysm clips, prostheses, etc.). High magnetic fields may also present safety hazards from the forces that they exert on ferromagnetic materials such as tools.

Radio-frequency (RF) and microwave radiation is present at most accelerator facilities. Typical primary sources are klystrons, magnetrons, and backward wave oscillators. For most microwave installations, high system performance and safety are mutually reinforcing goals; radiation leaks that expose people also adversely affect the performance of the system.

Both magnetic fields and RF fields can interfere with some radiological survey instruments.

b. Guidance

(1) The American Conference of Government Industrial Hygienists (ACGIH) specifies guidelines for personnel protection in the form of Threshold Limit Values (TLVs). Use of these guidelines, in their most current form for static magnetic fields and RF/microwave radiation, are mandated by DOE 5480.4.

(2) To avoid exposure of persons to unacceptable levels of RF fields, engineered control measures, such as shielding, prevention of wave guide leakage, enclosures, interlocks preventing accidental energizing of circuits, and dummy load terminations, should be given first consideration over any use of personal protective equipment. Where exposure in excess of the limits is possible, RF leakage tests should be conducted when the system is first operated and after modifications which might result in changes to the leakage. Area RF monitors are appropriate when RF energy can be expected in occupied areas.

E. Fire Protection and Life Safety

1. Discussion

Although the Accelerator Safety Order does not have specific fire protection and life safety requirements, this guidance is being provided as one approach for the assessment of the risk associated with potential fire and the inclusion of adequate mitigative features in the design, and operation of an accelerator facility.

DOE Order 440.1, requires compliance with the National Fire Protection Association Codes, including “Life Safety Code” (NFPA Standard 101). This guidance will not restate those requirements; it will instead provide a logical method for the analysis of the fire hazard in an accelerator enclosure to provide equivalent means for complying with the Life Safety Code's prescriptive requirements.

2. Guidance

a. Basic Emergency Egress Requirements

The Life Safety Code allows a range of travel distances to an exit, depending on how the occupancy of the facility is defined. Given the qualitative nature and the inherent uncertainties of occupancy classification, the use of a hazard analysis could provide the best basis for assessment of fire risk and life safety.

b. Property Protection Issues

In addition to the life safety requirements, protection of property may necessitate fire suppression requirements for some environments. Again, a hazard analysis could be used to provide a more precise fire risk assessment.

c. Analytical Methodology

Analytical methods could be used to establish a basis for safe travel distances to exits. One method is described here, although there are many others that could be employed.

(1) Design Basis Fire

Establish the parameters of the fire against which the occupants are to be protected (i.e., the Design Basis Fire (DBF)). The potential fuels (fixed and transient) in the accelerator enclosure should be identified, along with their combustibility parameters. The basic parameters required to predict the DBF from these fuels include: the chemical heat content; the physical form; quantity; characterization of the fuel as a “package,” the whole amount of which is likely to be involved in the fire; the identity of the worst case fire among the possible fuel packages; and the energy release rate over time to be expected from the fuel package, with supporting rationale (e.g., test data). Pertinent parameters of the accelerator enclosure are also used in establishing the DBF. These include the heat transfer parameters of the walls, ceilings, and floors; ventilation; and the physical dimensions of the accelerator enclosures.

(2) Use of Computer Models

The complexity of calculating fire effects lends itself to the use of computer fire models. The model used should be applicable to the specific situation (most often a ventilated tunnel).

(3) Decision Parameters

The data produced by the model should be sufficient to show where and when conditions untenable to human life develop. Typical hazards are loss of visibility, presence of toxic products above acceptable thresholds, or temperature above tolerable thresholds. Limits for these are readily available in the literature. This establishes the “available safe egress time.”

The designer then determines the time required for safe egress from the accelerator enclosure, i.e., the “required safe egress time.” This can be done by using anthropometric data on human walking speeds, human endurance, and the initial design for the distance between exits. Again, models could be employed.

If the time required for egress exceeds the time available, the designer revises the mitigative features used in the analysis, such as fire suppression systems, nonflammable materials, fire detection systems, ventilation, or travel distance to exits, and re-runs the model to see if the revised design will provide more safe egress time than is required. Some factor of safety should be employed to allow for the estimated uncertainties in the calculations.

(4) Property Damage Considerations

In addition to life safety considerations, the designer analyzes the susceptibility of the equipment in the accelerator enclosure to damage from fire and fire products. If the effects of the DBF would cause unacceptable damage to equipment within the accelerator enclosure, mitigative features such as automatic fire suppression systems should be installed.

(5) Other Life Safety Considerations

The possibility of leaks of cryogenic, toxic, or flammable liquids or gases, which may pose asphyxiation, fire, or explosion risks, are also considered in the design of the egress provisions. A leak of cryogenic fluids might displace the oxygen in the accelerator enclosure such that the ventilation and travel distance to an exit would not be sufficient to allow safe egress.

The density of the fluid involved in an incident affects the nature of the hazard greatly. Gases such as helium will travel horizontally along the ceiling of the accelerator enclosure until a vertical opening is reached, where they will follow that upward to perhaps a service building and potentially create an oxygen deficiency hazard (ODH). Gases that are denser than the ambient air, e.g. escaping liquid argon, will concentrate on the floor of the accelerator enclosure and will flow to lower areas, where they will accumulate and create an ODH condition. Provisions for egress should account for these conditions.

(6) Configuration Control

The success of the mitigative features depends on their being maintained as originally intended. If administrative controls are used, the management should commit to having strict materials controls for the life of the facility.

Engineering controls must be maintained in a state of readiness.

F. Experiment Safety

1. Discussion

Each experiment needs to be evaluated for its safety and health implications, and a safety analysis performed if it cannot be shown that the experiment clearly falls within the bounds that have already been analyzed and documented in another approved SAD.

2. Guidance

a. The safety implications of each experiment or set of experiments should be addressed in a SAD. The experimental activities may, in some cases, be adequately covered by a SAD written for an accelerator facility as a whole. To the extent practicable, the safety analysis of experimental work could address sets of experiments and establish the bounding conditions within which each particular set of experiments can be conducted in a safe and environmentally sound manner.

b. For each set of experiments, the safety analysis should identify the safety training needs, including who needs training, and the nature, content, and frequency of the training beyond the general safety orientation provided to all experimenters.

c. The scope and content of written and approved safety procedures for experiments should be appropriate to the safety, health, and/or environmental impacts the experiments present.

d. For each experiment, a written assessment of the safety and health implications should be made as early as possible in the design of that experiment. The assessment should compare the experimental conditions against the ASE using a checklist to ensure that all issues have been evaluated. The experiment should be briefly described and the hazards identified. The assessment should consider whether additional training and/or controls are required to perform the new experiment or if it can be reasonably considered as part of an existing set of experiments.

e. The contractor can authorize the initiation of the experiment if the assessment concludes that: the experiment falls completely within the bounds of a previously analyzed, documented, and approved set of experiments; the experiment's environmental, safety, and health characteristics are adequately controlled by the existing Accelerator Safety Envelope; and the contractor's independent internal review supports these conclusions. Where these conditions are not met, a safety analysis will be needed to support a request for DOE approval of the experiment.

f. Copies of operating safety procedures for experimental activities should be available to all individuals involved in those aspects of the experiment.

g. During the operational phase for most experiments, particularly complex or long lasting ones, periodic audits should be conducted with a frequency no less than annually to verify that no changes to the safety and health conditions analyzed in the Safety Assessment Document have occurred.

h. To avoid inadvertently exceeding the Accelerator Safety Envelope, a system should be employed that identifies which experimental apparatus, monitoring systems, and procedures cannot be changed without prior approval, and who is the approval authority.

III. Accelerator Readiness Review (ARR) Guidance

Introduction

An Accelerator Readiness Review (ARR) verifies the contractor's readiness to conduct specific activities within an accelerator facility. ARRs are conducted in accordance with the requirements established in DOE Order 420.2, "Safety of Accelerator Facilities." The contractor's declared readiness to proceed is established by findings that personnel, hardware, and procedures are ready for safely commissioning a system, for beginning routine operation, or for resuming an activity following a DOE-ordered ARR. Serious consideration should also be given to conducting an ARR after significant modifications to either the accelerator or the experimental program, or after an extended shutdown. The ARR is not intended as an evaluation of the overall ES&H program at a facility.

The Order places the requirement to perform ARRs solely on the contractor and requires that DOE ensure that the contractor's review was conducted with appropriate scope and depth. DOE also has the responsibility to verify that the findings/observations of the readiness review have been satisfactorily addressed/resolved by the contractor.

The purpose of this informal guidance is to provide a non-mandatory framework which, when followed using a graded approach, can provide adequate assurance that the ARR will satisfy the requirements of DOE O 420.2A in an efficient and cost-effective manner. This guidance is also intended to provide a suggested approach to the planning and post-review activities associated with the ARR process. The Guidance is designed to serve as a helpful resource for contractors conducting ARRs. The Guidance is not intended as an audit/assessment tool and should not be used as such without prior agreement between the contractor and DOE. The Guidance may be used in whole or in part as deemed appropriate by facility management. Facility management may also choose an alternate method by which to conduct the ARR. The responsible DOE Site/Operations Office/NNSA Field Manager should review any ARR method chosen by the contractor to ensure appropriate scope and depth.

A. General

1. Purpose

a. The purpose of an Accelerator Readiness Review (ARR) is to verify that the contractor's personnel, hardware and procedures are ready to permit the activity to be undertaken in a safe and environmentally sound manner. An ARR is not a method for achieving readiness but for verifying it. It is the responsibility of the contractor's line management to ensure readiness.

b. DOE 420.2A requires contractors to conduct ARRs prior to commissioning any segment of the accelerator facility, prior to routine operation, and as directed by the Cognizant Secretarial Officer/NNSA Deputy Administrator or DOE Field Element Manager/NNSA Field Manager.

[1] The purpose of a Commissioning ARR is to verify readiness to proceed with commissioning (or the next phase of commissioning). The Commissioning ARR should confirm, to the extent necessary to safely proceed with commissioning (or the next phase of commissioning), that construction is sufficiently complete, necessary construction tests have been performed and accepted, required safety-related systems are installed and operational, relevant procedures have been approved, and appropriate personnel have been assigned and adequately trained.

[2] The purpose of a Routine Operation ARR is to confirm that the facility is fully ready for routine operation, including that construction is complete, systems are fully tested and operational, procedures are established and operationally verified, staffing is complete, and personnel are fully trained.

c. The contractor should consider conducting an ARR if a facility has been shutdown for an extended period of time, or when significant modifications have been made to either the accelerator or the experimental program.

d. Where commissioning of an accelerator facility is accomplished in discrete segments, the ARR must also be performed incrementally.

2. Conditions for Conducting an ARR

a. Combined with the straightforward purpose of an ARR as stated above, it is intended that the process be flexible and that full use be made of a graded approach so that the necessary readiness is verified, but unnecessary costs and delays are avoided. Therefore, a readiness review may be undertaken and accomplished using a variety of methodologies, provided that it truly verifies the readiness of whatever activity facility management **<u>declares to be ready</u>**. This is the basic intent of any ARR.

b. Given this intent, the readiness review process should be sufficiently flexible to permit the review to be accomplished in a timely and efficient manner, while not sacrificing the synergy available only from a team effort. While it may be more efficient or cost-effective to conduct portions of the ARR during particular windows of opportunity, such efforts should be used judiciously so as not to adversely impact or preclude the synergism of interactions among team members.

c. The ARR should include applicable portions of support functions such as training, maintenance, health physics, environmental monitoring, waste management, and pollution prevention.

d. While this guidance addresses verifying the readiness of items important to ES&H, the scope of an ARR can be expanded as desired by the contractor's senior management to address other “best management practice” topics when such joint treatment is judged to be cost-effective.

3. The Role of DOE

a. The role of DOE Field Offices (Operations/Area/Site Offices) in the ARR process is to:

- Request the contractor to prepare a proposed ARR Plan of Action and submit it to DOE for acceptance;
- Evaluate the contractor’s proposed Plan of Action to assure appropriate scope and depth, and formally notify the contractor when it is found to be acceptable;
- Provide sufficient real-time oversight, supplemented where needed by first-hand sampling to support a determination by DOE of the appropriateness of the contractor's ARR results (Depending on the complexity of the activity being reviewed and other pertinent factors, DOE may elect to satisfy its determination by conducting its own ARR to verify the readiness of the proposed activity);
- Provide authorization to proceed when satisfied that the findings identified by the ARR have been adequately addressed;
- Keep Headquarters informed of the progress and results of ARRs; and,
- Require the contractor to perform an ARR when it determines other circumstances warrant.

b. The role of the cognizant DOE Headquarters organization in the ARR process is to:

- Provide guidance to the DOE Field Offices concerning ARRs; and,
- Monitor ARRs through the activities of the Field Offices to ensure appropriate scope and depth;

B. Pre-review Activities

1. Scope of the ARR

a. The ARR's objectives should be specified by the contractor senior manager who appointed the ARR Team.

b. From the objectives provided, the scope of the ARR should be defined by the Team Leader in consultation with the management of the facility to be reviewed. This scope should be documented and used in identifying the technical expertise needed for the ARR. A work breakdown structure or MORT diagram may be used to address the subjects mentioned in Sections 3, 4, and 5 of this guidance document to the extent they are appropriate for the review.

2. ARR Team Selection

The following considerations should be addressed when appointing an ARR Team:

a. An appropriate member of the contractor's senior management group (usually that individual having ultimate line responsibility for the facility to be reviewed) should appoint, in writing, an ARR Team Leader and ARR Team;

b. The size and specific capabilities of the ARR Team should be based upon the scope of the ARR;

c. The team members should be appointed based on their demonstrated objectivity and their expertise in one or more of the topics to be reviewed. Between them, the team members should have expertise in all relevant topics;

d. The team leaders and members should have no current involvement with the activity being reviewed, and past involvement should be sufficiently distant or of such a nature that team members are not in any way being asked to review a product that they had a significant part in creating (i.e., they should have reasonable independence from the activity they are being asked to review); and,

e. The ARR Team can be appointed and begin planning its review activities before facility management declares the proposed activity to be ready for the formal review.

3. Planning for On-Site Facility Review

To conduct an effective ARR, an on-site review of the proposed activity is necessary. The following considerations should be addressed during the planning:

a. ARR Team Members should be asked by the ARR Team Leader to prepare a Plan of Action for their component of the review, which summarizes their proposed methodology and acceptance criteria. (Review methodologies include those aspects of each requirement that the reviewer plans to address by some combination of evaluating procedures and/or other documentation, conducting interviews and performing first-hand observations or inspections). ARR Team Members should give careful consideration to the subjects addressed in Sections 3, 4, and 5 of this guidance document to the extent appropriate.

b. The extent to which the team can remain together rather than work as individuals in conducting the review should be carefully considered. The entire team should receive an orientation to the proposed activity early in the review effort, and periodic team discussions are desirable to discuss concerns or promote consensus.

c. Team members should develop their review schedules with adequate time for the completion of their review activities, having given consideration to the availability of appropriate facility staff.

d. Facility management should confirm that measures have been taken to ensure team access to necessary personnel and to appropriate locations (security clearance ascertained, Personal Protective Equipment supplied where appropriate).

e. The Team Leader should arrange with facility management for the logistic support necessary for an efficient review (workspace, access to personnel and necessary information, and availability of support equipment such as computers, telephones, etc).

4. Conducting the Readiness Review

a. ARR Team members will receive general direction from the ARR Team Leader, who is immediately responsible for assuring that a quality review is performed and documented.

b. ARR's should be conducted to the extent possible using a "hands-on" approach involving observations of the condition of hardware and of the performance of personnel involved in the activity under review.

c. The final draft conclusions of the ARR should be communicated verbally to appropriate staff of the activity under review immediately upon the conclusion of the review. This meeting between the ARR Team and the involved personnel should be interactive so that the final conclusions resulting from the review are accurate. Disagreements between the ARR Team and the involved personnel need not be resolved, but should be identified in the ARR Report, which should be finalized promptly after the meeting with facility personnel.

C. The Review: Documents

1. Accelerator Safety Envelope

The ARR should verify that:

a. An Accelerator Safety Envelope (ASE) has been developed in accordance with DOE Order 420.2A.

b. The ASE has been reviewed by an independent safety review system internal to the contractor's organization. The results of that review have been received by contractor management and considered;

c. DOE has approved the ASE for the proposed activity or, as a minimum, has received the proposed ASE for approval; and,

d. The procedures addressing ASE required equipment and systems specify the minimum necessary system components and monitoring devices to allow operation. In the event these minimums are not met, actions are specified.

2. Safety Assessment Document

The ARR should verify that:

a. A Safety Assessment Document (SAD) (or its equivalent) exists, has been reviewed by the contractor's internal independent safety review system, and the comments and recommendations resulting from that review have been adequately addressed by management; and,

b. Contractor management has documented its conclusion that the activity analyzed in the SAD is an accurate evaluation of the ES&H consequences of undertaking the activity, and that the mitigated risks of the activity to employees, the public, and the environment are acceptably low.

3. Procedures

The ARR should verify that:

a. Procedures necessary for safe operation of the activity have been developed, reviewed, verified (by performance where applicable), and approved;

b. A procedure control system has been established which defines the processes for procedure preparation, review, approval, verification, distribution, and training;

c. Maintenance activities involving the safety aspects of the activity being reviewed have been identified and maintenance procedures for these activities have been developed, reviewed, verified, and approved;

d. There is a system for assuring that procedures for safety-related operations and maintenance are kept current; and,

e. Procedures to deal with off-normal and emergency situations have been prepared and are approved for use.

4. Compliance with DOE ES&H Requirements

The ARR should verify that:

a. Facility management has required a review to be made of the activity's conformance to applicable ES&H requirements;

b. Nonconformances have been identified and schedules and resources for achieving compliance have been established and approved by the appropriate level of management;

c. There is a process for reviewing changes to the proposed activity for impacts on hardware, procedures, training, and unreviewed safety issues; and,

d. Processes exist for evaluating the readiness of radiological control measures and other ES&H items applicable to the proposed activity.

5. Resolution of Findings and Observations

The ARR should verify that:

a. A process exists to identify, evaluate, and resolve findings made by internal and external oversight and audit groups, and;

b. Previous findings made by internal and external oversight and audit groups, including prior Accelerator Readiness Reviews of the accelerator, which are relevant to the activity under review, have been satisfactorily completed or have corrective actions underway. ("Observations" do not require action on the part of the contractor.)

D. The Review: Hardware

1. Hardware Readiness

The ARR should verify that:

a. Equipment and systems having safety importance meet criteria described in the SAD and have been appropriately tested. This includes, but is not limited to:

- shielding
- electrical system isolation
- protection against credible fires
- protection from oxygen-deficient environments

- cryogen storage, transfer, and use
- beam transport
- high-power beam dumps
- Personnel protection systems, including secured area interlock system
- Fixed and portable radiation monitoring equipment
- Other instrumentation for monitoring safety and health conditions
- Systems for controlling environmental, safety, and health parameters

b. The results of testing conducted to confirm the readiness of hardware to undertake the activity safely have been documented, evaluated to ensure adequacy, and meet quality assurance requirements.

2. Hardware Operability

a. A program is in place to periodically reconfirm the status and operability of hardware systems having safety importance.

b. The performance of the physical systems that provide assurance of the viability of the ASE and that maintain the activity within the Operations Envelopes (when used), have been verified, and records of appropriate tests and calibrations of these systems exist and are current.

E. The Review: Personnel

1. Training Program

The ARR should verify that:

a. Training and qualification programs have been established for general safety orientation, accelerator operations personnel, maintenance and support personnel, experimenters using the facility, and emergency responders. These training and qualification programs are documented and encompass the range of duties required to be performed in accordance with the SAD, and;

b. A process to evaluate training program effectiveness on a periodic basis has been established and documented and specifically includes the following considerations:

[1] Classroom and individualized instruction are appropriate for the facility, and facility management periodically evaluates instructor performance;

[2] A systematic evaluation of training program effectiveness, including feedback from job performance, is used to ensure the training program conveys all the required skills and knowledge;

[3] The personnel protection training program is specific to the facility's hazards and provides the knowledge and skills necessary for individuals to perform their assigned job functions while avoiding exposure to specific facility hazards such as high voltage, cryogens, and oxygen deficient environments, and minimizing their exposure to radiation and chemicals; and,

[4] Training and qualification of personnel has been achieved.

2. Qualified Personnel

The ARR should verify that:

a. The numbers of trained and qualified operations, maintenance and support persons meet SAD or ASE requirements;

b. Individual assignments, responsibilities, authorities, and reporting relationships are defined, documented, and included in training; and,

c. Qualifications or exceptions to specified areas of training, based upon education or experience and have been granted and documented by a designated contractor manager.

F. Post ARR Efforts

1. ARR Report

a. An ARR report should be prepared as soon as possible after the completion of the review. The ARR Team Leader should obtain input from all team members and the team should reach consensus on the readiness of the facility to commence the activity for which the ARR was performed.

b. The conclusions reached by each team member are the principal end-product of the ARR. They should be carefully drawn so that they unambiguously reflect the true intent of the team member, and they should be supported just as carefully. Suggestions of the types of information that will help support the conclusions include: methodology used in pursuing the review, personnel contacted and their positions, documents reviewed, evolutions/operations witnessed, spaces visited, etc.

c. A conclusion drawn as a result of the ARR effort may lead to one or more findings and/or observations. Findings are more serious and require documented closure. Findings reported by the team should be categorized as Prestart or Post-start Findings. A Prestart Finding is one that, in the Team's opinion, must be corrected before an activity can be started. A Post-start Finding can be corrected after the start of the activity under review. One possible approach to categorizing findings is presented in Attachment B.

d. The final ARR Report should be directed to the designated contractor senior management official, with an information copy to the appropriate DOE Operations Office Manager (or designee) and to the DOE/HQ Program Office. Each team member should also receive a copy of the ARR Report. The contractor senior management official will be responsible for any further distribution of the report.

e. The following format for the ARR Report is suggested but not prescribed; different formats may be used as agreed upon by the ARR Team Leader and the contractor senior management official.

- **Title/Cover Page** - State the subject and date of the ARR.

- **Signature Page** - Include the signatures of all team members, signifying their agreement with the report and its conclusions. If a signature cannot be obtained for logistical reasons, the ARR Team Leader should obtain concurrence verbally or by facsimile and sign for the member.

- **Table of Contents** - Identify all sections (including page numbers), subsections, illustrations, tables, charts, and appendices.

- **Executive Summary** - Provide a summary of the review, findings and facility readiness. Suggested considerations include:

- A brief synopsis of the review;
- A determination as to readiness of the facility to undertake the activity;
- A statement regarding the adequacy of management systems to oversee the activity;
- A synopsis of the significant problems and strengths found by the ARR; and,
- A brief summary of the findings including numbers of prestart or post-start findings.

- **Introduction** - Provide background information regarding the activity under review. This should include:

  - Purpose, scope and objectives of the ARR;
  - Review process and methodologies;
  - Composition of the ARR Team; and,
  - Definitions applicable to the ARR.

- **Conclusions** - Address each subject identified in the scope and discuss the facility's readiness in each area. State each finding succinctly and unequivocally, and characterize as prestart or post-start. Provide the basis for each finding.

- **Observations** - Identify those items, which, in the opinion of the ARR team member, do not require action by the contractor but would likely enhance the ES&H status of the facility.

- **Readiness Determination** - Provide an overall recommendation as to the readiness of the facility to commission, restart or routinely operate.

- **Appendices** - Append data/documents to support the report. These should include:

  - Review criteria and approach;
  - Team roster with relevant qualifications of each member; and,
  - Differing opinions (when applicable).

2. Lessons Learned

It may be useful to future ARR Teams and to the contractor's senior management group to document any lessons learned from the ARR. Problems and successes encountered during the ARR process should also be addressed. Either the ARR Team or the facility management could prepare this document, or it could be jointly prepared.

3. Team Disbandment

With the delivery of the ARR Report to the designated contractor senior management official, the team should be formally disbanded by that official (this commonly will also have been the appointing official). After disbandment, Team Members, at the discretion of the contractor senior management official, may be requested to provide assistance relative to responses to the reports findings.

4. Disposition of ARR Findings

a. The designated contractor senior management official should transmit the ARR Report with its findings, including any specific commentary and instructions that this official feels are appropriate, to the facility's management. This transmittal should request a written response.

b. The management of the evaluated facility should provide a written response to the designated contractor senior management official that addresses each finding individually. The response should include a plan, which defines the actions that will be taken in response to the finding, including a schedule for completion.

c. At the senior management official's discretion, ARR team members should be requested to evaluate the responses to their findings, and provide that evaluation in writing to the requesting official.

d. The need for follow up visits by former ARR Team members or other experts, as well as the scope of the visits, should be based on the significance of the findings, as well as on the facility management's responsiveness to the findings.

e. All follow up visits should be documented to identify the scope and purpose of the visit and to provide a determination as to the adequacy of the facility's action(s) with respect to the findings for which the visit took place. The documentation generated by all follow up visits should be included in the official review file.

f. If a follow up visit identifies additional findings or insufficient progress on commitments made to address the ARR Report's findings, the management of the evaluated facility should also provide a written response to those items.

5. Approval to Proceed

a. When the contractor's senior management determines that the activity is ready to be undertaken, this determination is to be formally communicated to the DOE Operations Office Manager/NNSA Field Manager (or his/her designee) with an information copy sent to the Program Office.

b. DOE authorization to undertake the activity is to be in accordance with the conditions provided in DOE 420.2A.

c. The contractor is not to undertake the activity without the prior written authorization of the DOE, except for the resumption of activities shut down solely by the contractor.

ADDENDUM A: ARR FINDINGS CLASSIFICATION CRITERIA

This checklist may be used by the ARR team to evaluate if a finding must be corrected prior to startup.

A. Initial Screening

1. Does this issue involve equipment or a system having safety importance?

2. Does this issue involve processes, functions or components identified in the Accelerator Safety Envelope?

3. Does this issue involve potential adverse environmental impact exceeding regulatory or site specific release limits?

4. Does this issue impact non-safety processes, functions, or components, which could adversely impact processes, functions or components having safety importance?

5. Is this issue non-compliant with a company or Operations Office approved startup directive?

6. Does this issue indicate a lack of adequate procedures or administrative systems having safety importance?

7. Does this issue indicate operational or administrative non-compliance with procedures or policy having safety importance?

8. Has this issue occurred with a frequency that indicates past corrective actions have been lacking or ineffective?

9. Does this issue require operator training having safety importance not specified in existing facility training requirements?

10. Does the issue involve a previously unknown risk to worker or public safety and health or previously unknown threat of environmental insult or release?

If the response to any of the above is yes, further evaluation, in accordance with the issue impact criteria below, is required. If the response to all of the above is no, the issue may be resolved after restart.

B. Issue Impact Criteria

If the response to any of the questions below is yes, the item should be considered a prestart activity.

1. Does the loss of operability of the item prevent safe shutdown, or cause the loss of essential monitoring?

2. Does the loss of operability of the item cause operation outside the Accelerator Safety Envelope?

3. Does the finding indicate a lack of control which can have a near term impact on the operability or functionality of equipment or subsystems having safety importance?

4. Does the finding involve a violation or potential violation of worker safety or environmental protection regulatory requirements that poses a <u>significant danger</u> to workers, the public, or of environmental insult or release?

ADDENDUM B: SUMMARIES OF PREVIOUSLY CONDUCTED ARRs

The following appendix contains summaries of ARR approaches used by three DOE accelerator facilities. Since these ARRs were conducted prior to the development of the ARR guide, these summaries should not be expected to match the guidance. They are included to illustrate the flexibility and tailored approach intended for the ARR process. There are many approaches that satisfy DOE Order 5480.25 when applied with appropriate rigor.

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Advanced Photon Source (APS)
Accelerator Readiness Review (ARR) Process Summary

The ARR process followed for the APS occurred in three distinct stages: modular commissioning of the accelerator systems, establishment of an experimental beamline commissioning process, and commencing routine operation. The requirements of DOE 5480.25 were adhered to throughout these stages. As specified in the Order, APS management assumed responsibility for, and managed, the process of assuring that technical reviews were conducted, procedures developed and that due consideration was given to safety. The modular approach to commissioning, as specified in DOE Order 5480.25, was adopted as it best approximated the design, construction and testing sequence that was planned for the assembly of APS system components prior to the implementation of the Order.

Though some details of the ARR process for each stage were unique to that stage, the overall process involved the following:

1) An Accelerator System Safety Assessment Document (SAD) was prepared for the first commissioning module. The SAD was reviewed by an ANL safety committee convened for that purpose and then provided to the DOE Chicago Operations Office Argonne Group (DOE-ARG) prior to initiating the ARR for the commissioning module. This SAD was revised to address each subsequent commissioning module during the accelerator systems assembly, amplifying on the previous SAD revision as needed. Each SAD revision also was reviewed by the ANL safety committee and submitted to DOE-ARG prior to initiating the ARR for that commissioning module. As a result a SAD existed addressing all the hazards associated with the accelerator operation and maintenance before the final commissioning module for accelerator systems received its ARR. An addendum to the SAD was then prepared to address the hazards associated with the experimental beamlines. This addendum was reviewed by the ANL safety committee and provided to DOE-ARG prior to the ARR for the experimental beamline commissioning process. A final SAD supporting commencement of routine operation was later prepared that incorporated the addendum and any revisions brought about as a result of commissioning experience. Once again the final SAD received an internal laboratory review and was provided to the DOE-ARG before initiating the ARR for routine operation. In all cases an Accelerator Safety Envelope

(ASE) was prepared and included as a chapter in the SAD. DOE-ARG approval of the ASE was required before initiating each commissioning module and routine operation.

2) A readiness tree was prepared for each commissioning module and each stage. The readiness tree consisted of three main branches: hardware, management system, and personnel training. The readiness tree, together with supporting documents, described the commissioning or operating requirements that had to be completed to proceed. Each readiness tree branch included sublevel blocks representing readiness of a particular component of the main branch. Each sublevel block had a separate sign-off sheet contained in an accompanying document. Each sign-off sheet was further broken down into individual items requiring completion prior to beginning commissioning or operating activities. These were further classified into safety or non-safety critical items.

3) A separate ARR team was formed for each stage. The APS Project Director identified a team leader who then assembled an ARR team. The readiness review teams were composed of members from line organizations outside of APS and, where necessary, outside of the Laboratory. A charge was prepared for each ARR team to follow. The ARR teams were charged to advise APS management if:

   (1) The hardware of technical and conventional facilities was ready to be commissioned or operated;

   (2) Managerial control and procedures were ready; and,

   (3) Personnel were adequately trained and ready for the proposed activities.

In addition to these three items, each ARR team was asked to verify that there were no outstanding items from the safety assessment review of the SAD that would preclude commissioning or operation. The ARR teams were provided with the readiness trees and associated sign-off sheets. The ARR teams were asked specifically to confirm that safety items had been adequately identified as well as completed.

The ARR teams attended presentations by facility personnel, and toured the facility segment under consideration. The team members were directed by the team leader to perform spot checks and completeness verification as deemed necessary. The ARR team provided to the facility management a written finding of the review and scheduled subsequent meetings of the team and APS personnel when necessary.

The ARR performed for the initial commissioning module included numerous spot checks and completeness verifications to confirm that the APS readiness management system was in place and functioning as described. The subsequent commissioning module ARRs focused on specific issues involved with the commissioning module being reviewed and fewer spot checks were performed as it had been demonstrated to the ARR team's satisfaction that the APS internal verification process of completion was well established and being followed.

Unique details of importance included the following:

1) Experimental beamlines will be installed or modified throughout the life of the APS. The APS experimental beamlines are designed, installed, commissioned, and operated by Collaborative Access Teams (CATs) rather than by the APS staff. The CATs are semi-autonomous entities with individual organizations, operating and safety procedures, and experiment reviews processes (all of which must conform to APS stipulated requirements). The APS staff acts as the independent reviewer for the CATs. The APS staff has developed an ARR process for beamline commissioning. The beamline ARR process includes modular commissioning of an individual beamline as separate experiment stations are completed or modified. A separate ARR was performed of the process to ensure that the appropriate information was being verified. This review determined the readiness of the process rather than of specific equipment. The conclusion was that the process was adequate and could be used to commission each beamline.

2) The ARR for commencement of routine operation involved a joint effort from ANL and DOE-ARG. The DOE-ARG reviewers performed several detailed vertical slice reviews of specific systems. These reviews started with the APS policy and procedures and traced implementation through to the actual floor installation and operation. A separate report was prepared for each vertical slice review. Based on the performance of these DOE-ARG reviews and the continued applicability of the commissioning ARRs, a limited ARR was conducted by ANL. The ANL ARR concentrated on ensuring that the readiness tree for routine operations included all proper administrative elements, verified that outstanding items from previous ARRs had been closed, and reviewed commissioning experience for the topics of electrical safety and radiation safety interlock systems.

Upon completion of each ARR, and in accordance with DOE Order 5480.25, approval for commissioning or operation was solicited from DOE.

Appropriate DOE personnel from ARG, CH and HQ participated in the review process as observers to ensure DOE personnel awareness of the review and its contents.

The following lessons were learned from the APS ARRs:

1) Each stage of the ARR process was preceded by a review of a SAD associated with that stage. Having an already reviewed SAD addressing the applicable commissioning stage enhanced the ARR process and added validity to its conclusions.

2) The initial commissioning module ARR was the most detailed. The remaining ARRs of the commissioning modules built upon this initial detailed review and benefited greatly from it. A valuable lesson for a modular ARR process is that each step of that process does not need to review items covered in previous steps if the initial review established a good baseline; only new developments pertinent to subsequent modules need to be examined in detail.

3) There were several separate ARR teams involved through the ARR process. Each ARR team had a slightly different perspective and method of documenting their review. The format of the documentation was highly dependant upon the team leader. Each report was processed separately and at a different point in time. This resulted in a variety of report styles that could be somewhat confusing when reading through all ARR reports. As each report provided an acceptable basis for DOE-ARG approval for initiating a specific commissioning or operating stage, the conclusion is the variety of reporting styles did not detract from the adequacy of the individual reviews (i.e., the information provided was more important than the format).

"PHASED ACCELERATOR READINESS REVIEW"
Advanced Light Source

Facility Description: Total renovation of an existing accelerator facility into a new $100M synchrotron radiation "DOE User Facility."

Location: SF Bay area; within 40 minutes of the Oakland Operations Office and several major existing accelerator facilities.

Program Considerations: Several industry Users express urgency to get started with research. HQ program office desires to exhibit "can do" capability to industry.

Type of Accelerator Readiness Review: "Phased." As each individual element of the MORT-type readiness tree is readied for review, the facility management certifies to the independent review team leader and the DOE validation team leader that the element is complete and ready for operation. The independent reviewer then performs his review of that element. The DOE validator verifies that the reviewer is qualified, that the review has been appropriately in-depth, and may perform an additional "sampling" type of independent review.

Reason for Selection of Type of ARR: Achieves a thorough ARR with minimal schedule impact. Facilitated early accommodation of Users. This type of review, however, can only be performed where there are convenient, nearby resources of available independent reviewers and DOE validators.

Documentation of Findings: Each independent reviewer and DOE validator is required to plan their reviews and develop a one page list of topics/items to be reviewed/checked. During reviews, the reviewer/validator annotate their review lists with short notes of what was checked/observed and who was interviewed. The hand annotated lists are maintained as part of the ARR record to provide objective evidence of the thoroughness of the review and the rationale behind any findings. Any findings by the independent reviewer are documented on a "Comment/Issue" form. The facility cognizant person must concur with the finding and must develop a resolution; the independent reviewer must concur with the resolution. If the ODE validator has any additional findings, the independent reviewer must concur with the finding and resolve the finding with the facility as just described.

Resolution of Disputes: This ARR method -- where the independent reviewer and the facility cognizant person must concur on findings and resolutions, and where the DOE validator findings must be accepted by the independent reviewer -- produces very few disputes which must be elevated. The facility cognizant person, the independent reviewer, and the DOE validator are similar expertise and are capable of resolving conflicts and reaching consensus between themselves.

Lessons Learned: The obvious benefit of this method is that it minimizes schedule impact. A less obvious benefit is that it facilitates early identification of problem areas that, if not identified early, could delay operation of the facility. The major disadvantage of this method is that it demands more effort by reviewers to review each element as it is certified as ready, and it demands more effort by the ARR coordinator(s) to keep track of what is ready for review, what has been reviewed, and the disposition of findings.

"CEBAF ACCELERATOR READINESS REVIEW"

The CEBAF ARR was conducted using a four-phased approach. As the installation of each major actions of the facility was completed, the section was subjected to the ARR process; the injector, 1st LINAC, full accelerator and loop, and 1st experimental hall. Each reviewed used a logic tree to identify the ARR scope, followed by the development of assessment criteria to determine the readiness status of each sub-system. Dr. Boyle stressed two points: 1) the basis of the CEBAF process was a three-tiered review consisting of sub-system self-assessments conducted by managers responsible for the subsystem, followed by an internal review by in-house cognizant experts in the same professional discipline, and finally examination by a panel of nationally recognized professional from outside the CEBAF organization, and 2) in-depth planning of the scope and review criteria significantly decreases the amount of time required for on-site verification.

Facility Description: "CEBAF is a 4 GeV continuous electron beam accelerator facility using superconducting technology to provide three fixed target experimental halls with basic nuclear physics research capabilities."

Location: Newport News, Virginia.

Program Considerations: Installation schedule required pre-commissioning tests for some components at the same time that other components were being installed. Furthermore, the experimental halls sequentially become available for Users ('94, '95, & '96).

Type of Accelerator Readiness Review: "Phased." The CEBAF Readiness Plan was negotiated with the DOE review readiness for five key machine milestone points: Injector; Low power linac tests; Higher power linac and beam transport tests; Full accelerator, recirculation, beam switchyard, and beam to first experimental hall; and Final two experimental halls. Readiness self-assessments (by cognizant and responsible subsystem line managers), internal review (by knowledge CEBAF experts in the specific professional field - ARR Team member), and independent external review committee (nationally recognized experts in the fields of inquiry) occurred prior to each part of the facility becoming available for pre-commissioning and commissioning tests. DOE CEBAF Site Office and others for the DOE observed the process.

Reason for Selection of Type of ARR: Achieved a thorough ARR at the appropriate point in the project to maximize safety and Readiness confidence.

Documentation of Findings: Line managers performed self-assessment based on criteria developed by the ARR Team. A one-page summary document certified the readiness status at the time of the assessment. The objective evidence was then reviewed by a knowledge expert in the field of the subsystem being examined. Both line mangers and ARR Team reviewer signed the summary document. Findings identified are then tracked to closure with other summary pages. All specific documents are maintained by the subsystem line manager. Only the summary documents are maintained by the ARR Team Leader.

Resolution of Disputes: Any comment or concern is automatically assigned the next highest category of finding whenever disputes occur. (e.g., if a line manger identifies a finding as a "concern" and the ARR Team disputes the identification, then the finding automatically becomes an "issue" which must be close prior to achieving Readiness.)

Lessons Learned: Work out the ARR plan with the DOE. Charter the Team by the Director. Have Team develop the readiness tree and the readiness criteria. Develop a firm closure process.

Appendix A: Acronyms

ACGIH	American Conference of Government Industrial Hygienists
ALARA	As Low as Reasonably Achievable
ANL	Argonne National Laboratory
ANSI	American National Standards Institute
APS	Advanced Photon Source
ARR	Accelerator Readiness Review
ASE	Accelerator Safety Envelope
ASO	Accelerator Safety Order
CAT	Collaborative Access Team
CEBAF	Continuous Electronic Beam Accelerator Facility
CFR	Code of Federal Regulations
CSO	Cognizant Secretarial Officer
DBF	Design Basis Fire
DOE	United States Department of Energy
DOE-ARG	DOE Chicago Operations Office Argonne Group
D&D	Decommissioning & Decontamination
EH	Office of Environment, Safety and Health
EPA	United States Environmental Protection Agency
ES&H	Environment, Safety & Health
MOC	Management of Change
NCRP	National Council on Radiation Protection
NEPA	National Environmental Act
NFPA	National Fire Protection Association
NNSA	National Nuclear Security Administration
ODH	Oxygen Deficiency Hazard
OSHA	Occupational Safety and Health Administration
QA	Quality Assurance
PAL	Programmable Array Logic
PLC	Programmable Logic Controller
RF	Radio Frequency
SAD	Safety Assessment Document
SC	Office of Science
TLV	Threshold Limit Value
USI	Unreviewed Safety Issue

Appendix B: Definitions

a. Accelerator is a device employing electrostatic or electromagnetic fields to impart kinetic energy to molecular, atomic or sub-atomic particles and, for purposes of this Order, capable of creating a radiological area.

b. Accelerator Facility is the accelerator and associated plant and equipment utilizing, or supporting the production of, accelerated particle beams to which access is controlled to protect the safety and health of persons. It includes experimental enclosures and experimental apparatus utilizing the accelerator, regardless of where that apparatus may have been designed, fabricated, or constructed.

c. Accelerator Readiness Review is a structured method for verifying that hardware, personnel, and procedures associated with Commissioning or Routine Operation are ready to permit the activity to be undertaken safely.

d. Accelerator Safety Envelope is a set of physical and administrative conditions that define the bounding conditions for safe operation at an accelerator facility.

e. Approve means to confirm that a proposed contractor activity has acceptable safety and health implications.

f. Authorize means to give a right to undertake an activity; as applied to contractor activities, this action is reserved for the DOE Contracting Officer.

g. Authorization Basis is defined as that set of documents or requirements upon which a decision is made by DOE whether to authorize the commencement or continuation of activities. For the purpose of a DOE accelerator facility subject to DOE O 5480.25 or successor Orders, the authorization basis includes: (1) a DOE approved Accelerator Safety Envelope; (2) a Radiation Shielding Policy approved by top management for the accelerator facility; (3) a Safety Assessment Document approved by top management for the accelerator facility; (4) an Accelerator Readiness Review, as appropriate or needed since promulgation of DOE O 5480.25, November 3, 1992, and consistent with the responsibilities outlined in part 5.b. of DOE Order 420.1 Safety of Accelerator Facilities; (5) establishment of training and qualification requirements, and a safety review system approved by contractor management, which could be described in the site Integrated Safety Management System description; and, (6) operating procedures approved by contractor management.

h. Cognizant Secretarial Officer (CSO) is a senior outlay program official and includes: the Assistant Secretaries for Energy Efficiency and Renewable Energy; Defense Programs; Environmental Management; Fossil Energy; and Nuclear Energy; and the Directors of Civilian Radioactive Waste Management; and Energy Research.

i. Commissioning is the process of testing an accelerator facility, or portion thereof, to establish the performance characteristics. It starts with the first introduction of a particle beam into the system.

j. Exclusion Area is an area that is locked and interlocked to prevent personnel access while the beam is on.

k. Experimenters means all persons directly involved in experimental efforts at the accelerator facility utilizing the accelerator or its beams, including visiting scientists, students and others who may not be employees of the operating contractor.

l. Hazard means a source of danger (i.e., material, energy source, or operation) with the potential to cause illness, injury, or death to personnel or damage to a facility or to the environment (without regard for the likelihood of a harmful event occurring or of consequence mitigation).

m. Maintenance Personnel means not only those in the specialized crafts generally associated with maintenance activities, but also accelerator operations personnel and experimenters to the extent that they undertake to repair, maintain, or improve safety-related equipment.

n. Radiological Area means any area requiring posting as a radiation area, contamination area or an airborne radioactivity area as these terms are defined by Title 10 Code of Federal Regulations Part 835 AOccupational Radiation Protection; Final Rule.

o. Risk is a quantitative or qualitative expression of possible harm, which considers both the probability that a hazard will cause harm and the amount of harm.

p. Routine Operation of an accelerator commences at that point where DOE authorization has been granted either (1) because the Commissioning effort is sufficiently complete to provide confidence that the risks are both understood and acceptable and the operation has appropriate safety bounds, or (2) to permit the re-introduction of a particle beam after being directed to cease operation by DOE because of an environmental, safety, or health concern.

q. Safety Analysis is a documented process to systematically identify the hazards of a given operation; describe and analyze the adequacy of measures taken to eliminate, control, or mitigate the hazards and risks of normal operation; and identify and analyze potential accidents and their associated risks.

r. Safety Assessment Document is the document containing the results of a safety analysis for an accelerator facility pertinent to understanding the risks of the proposed undertaking.

s. Unreviewed Safety Issue exists if a proposed change, modification or experiment will:

(1) Significantly increase the probability of occurrence or the consequences of an accident or malfunction of equipment important to safety from that evaluated previously by safety analysis; or

(2) Introduce an accident or malfunction of a different type than any evaluated previously by safety analysis that could result in significant consequences.